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The Nature of Digital Extension Services in the Developing World

The Case of Kenyan Digital Agriculture Extension Services

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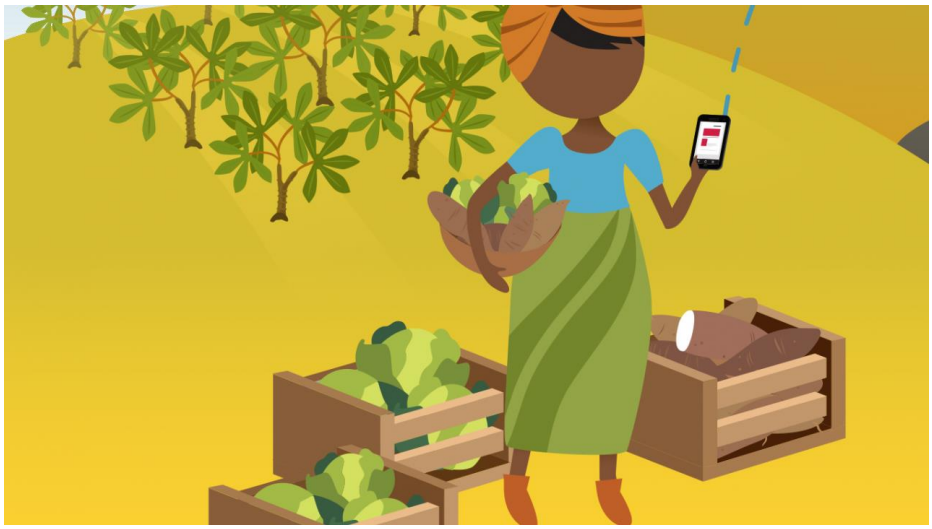

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Abstract

The rapid diffusion of mobile phones and the internet in Kenya is hoped to be an effective solution to meeting the crucial information needs of smallholder farmers to improve their economic and environmental resilience. This thesis conducts a case study based on interviews with actors who provide digital agricultural extension services to farmers in Kenya to assess the Agricultural Innovation System (AIS), and its features and current trajectory. It finds that the sector constitutes the stagnation phase of an opportunity-driven trajectory. Vital to the AIS is the role of international donors and NGOs, who have fueled the rapid growth of digital extension services leading to a heavily saturated and fragmented sector, whereby collaboration mirrors the cyclical and short-term nature of donor funding and NGO projects. Networks amongst Kenyan actors are rarely sustained without international involvement, and the emphasis on funding towards a social impact, however important, has neglected the financial sustainability of the services. The building of trust across actors, and especially smallholder farmers, is hampered as the high turnover in the sector leads to fatigue due to the constant registration required to utilize services and a growing digital confusion resulting from the superfluous number of digital services and the lack of coordination between them. The public sector was found to be passively supportive in terms of the underlying ICT infrastructure in Kenya but not well-aligned with the needs of the private sector and the digital extension services themselves due to a pervading lack of trust between both sectors. Digitalization was found to also provide creative opportunities for interaction with smallholder farmers to improve inclusivity in the sector, yet in-person interaction is still viewed as vital in this regard. Conventional roles occupied within the agricultural value chain, such as intermediaries and extension officers, were not transformed by digitalization as has been posited, rather the tasks associated with their roles have been redefined rather than replaced.

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Figures and Abbreviations

AIS Agricultural Innovation System

ASTGS Agricultural Sector Transformation and Growth Strategy

CIG Common Interest Groups

Cropmon Crop Monitoring Service

ICT Information Communication Technologies

KALRO Kenyan Agriculture and Livestock Organization

MOALFI Ministry of Agriculture, Livestock, Fisheries, and Irrigation

NGO Non-Government Organizations

NALEP National Agricultural and Livestock Extension Program

SAPs Structural Adjustment Programs

SDG Sustainable Development Goals

SSA Sub-Saharan Africa

TEAMS The East Africa Marine System

1. Introduction

1.1 Research Problem

The agricultural sector remains a vital source of livelihood in Sub-Saharan Africa (SSA) and is therefore linked to achieving development outcomes, such as those detailed by the Sustainable Development Goals (SDGs). Kenya, the 4th largest economy in SSA, is no exception. 72 percent of the population live in rural areas with 54 percent actively employed in agriculture contributing to 23 percent of overall GDP (World Bank, 2022a; b; c). A vast majority of them are smallholder farmers who produce 63% of total food production (Rapsomanikis, 2015). Considering a growing population and middle class with evolving changes in dietary preferences there is a pressing need to increase agricultural productivity amongst smallholders to accommodate for the growing demand for food and combat food insecurity (Osiemo et al, 2021). However, productivity, particularly amongst staple crops, has stagnated in recent decades and is unable to accommodate the growing population (Kogo et al, 2020). Agricultural practices have also received attention concerning their environmental sustainability, not only in the mitigation of ecologically harmful activities but in the adaptive capacity, particularly of smallholder farmers, to respond to growing pressures from climate change and extreme weather events which have become increasingly common in Kenya (Mulinge et al. 2016).

Whilst the challenges smallholders face in increasing agricultural production are multifaceted, this thesis focuses on the issue of access to information and inputs. Knowledge deficits in agriculture hamper farmers in several ways. Firstly, farmers are vulnerable to exploitation on behalf of the intermediaries they often rely on to sell their crops as their bargaining power is constrained by either a lack of knowledge of market prices or an inability to act upon available knowledge. The latter may be a result of their remoteness or the involved relationship they may have with the intermediary. This results in the income they receive is not proportional to the value of their produce (Deichmann et al. 2016). Secondly, effective crop management is not universally employed due to either a lack of awareness or understanding of its benefits and reliance instead on traditional methods, such as continuous cropping, which tend not to be as effective or environmentally sustainable (Dalimer et al., 2018). Thirdly, farmers lack access to weather information and meteorological data. This would help improve farmers' resilience to changes in weather and better accommodate for increasingly abrupt and unpredictable weather events. Lastly, the availability of financial resources and agricultural inputs is also a critical factor in determining a smallholder's productivity (Krell et al, 2021). Important in improving and providing information to farmers are the available extension services that allow for linkages between research and farmers to be facilitated. Extension services for this thesis can be defined as the dissemination of knowledge to “advance not alone production knowledge but the whole range of agricultural development tasks, such as credit, supplies, marketing and markets” (Rivera et al., 2001, p.9). Yet

as will be discussed in the background of this thesis and is indicated by the continuing low agricultural productivity in Kenya, they have largely been unsuccessful because of their limited scope, available resources, and the irrelevance of the information or constraints on effectively utilizing available information.

Considering the issues faced by agricultural extension services, the emergence of Information and Communication Technologies (ICT), notably mobile phones and the internet, has offered renewed hope for improving the reach and relevance of agricultural extension in Kenya. The country has done comparatively well in attracting investment into the ICT sector internationally, cultivating an environment that has been dubbed the "Silicon Savannah" due to the concentration of digital initiatives and start-ups (FAO and ITU, 2022, p.155). The digitalization that these investments have enabled has been argued by both international development agencies and the Kenyan public sector alike to possess significant potential for disseminating and fulfilling the information needs of smallholder farmers. In the form of either SMS services or smartphone applications, a plethora of digital agricultural extension services have emerged. According to Mabaya and Porciello (2020), Kenya has one of the largest concentrations of digital initiatives relating to agriculture in SSA, with about 115 having at least a local presence whilst 64 have their headquarters in the country (Mabaya and Porciello, 2020, p.72). It is argued that these services can effectively collapse the distance that had traditionally hindered previous extension services from reaching smallholder farmers and raise their productivity as information and knowledge can flow more freely across economic sectors and lowering overall transaction costs normally associated with agriculture in SSA (McCampbell et al, 2021). Yet despite the involvement of international and local actors and existing investment in ICT infrastructure, the adoption and use of these services amongst smallholder farmers remain low (Deichmann et al, 2016).

1.2 Scope and Aims

The scope of this thesis is to examine the agricultural innovation system (AIS) that facilitates digital agricultural extension services in Kenya. Before explaining the motivations for such an approach a few definitions are required. The concept of innovation is utilized in a broad sense, meaning that it is not only limited to inventions but also how existing elements, whether they may be technological, sociological, or institutional, can be reconfigured to produce novel solutions of economic and social significance. An innovation system is therefore the network of organizations, enterprises, and individuals active in producing these solutions as well as the institutions that shape their behavior and performance at a given level of analysis, which is in the context of this thesis confined to the digital agricultural extension services sector in Kenya (Hall et al, 2007, p.18). In this context, this research explores the way these networks of actors facilitate digital extension services in Kenya and how they are shaped by the public sector. The strengths and weaknesses of these linkages and flows of knowledge are important in the eventual effectiveness of the services

in disseminating information to farmers as well as how receptive digital extension providers are to shifting demands from farmers, other actors, or an exogenous change in the economic environment.

To do so, this thesis asks the following questions.

1. How do the different actors involved in digital agricultural extension services in Kenya shape collaboration and interaction amongst each other?
2. How supportive has the Kenyan public sector been of digital extension services?
3. How do the factors above reflect the trajectory of innovation in the sector?

The last question reflects this thesis's grounding in Hall et al's (2007) theoretical framework that assesses the features of an AIS at a given point in time, describing two different triggers to innovation referred to as the orchestrated and opportunity driven trajectories each involving several phases of development culminating in a dynamic AIS. By evaluating how different actors in the sector interact and collaborate and the role of the public sector as indicated by the first 2 questions, this research can then infer the trajectory and current phase of the sector. This allows for a descriptive analysis to be performed, and for the opportunities and challenges in the sector to be brought to the forefront. As mentioned previously, an innovation system involves a complex network of actors whose behavior both shapes and is shaped by the socio-political and economic context of Kenya. Previous research has thus far neglected how the nature of different actors' involvement in digital agricultural extension services shapes the kinds of collaboration and interactions amongst themselves, and how smallholder farmers are included in their development. This research aims to fill this gap. Implied by the low adoption of digital services despite their relative abundance is that the AIS experiences several idiosyncrasies and obstacles to its effective functioning. To understand why this is the case this thesis has conducted 5 interviews to highlight the nature of networks in the sector and the attitudes and practices of respective stakeholders towards collaboration and interaction. In doing so, the eventual findings of this research allow for a reconsideration of how different actors approach the sector and how the desired social and environmental outcomes can be realized for the benefit of smallholder farmers and the wider society.

1.3 Outline of Thesis

This thesis is organized as follows. Section 2 presents the context of previous extension services in Kenya and a brief description of the existing ICT infrastructure in the country. Section 3 describes the theoretical framework operationalized by this thesis. Section 4 discusses previous literature on the AIS Kenya and digital extension services more generally, as well as pointing out the gaps filled by this research. Section 5 details the methodological design of the research, as well

as acknowledging the limitations of the study. Section 6 presents the findings of this thesis and discusses them in relation to the theoretical framework and previous research. Section 7 concludes and provides recommendations for future research and policymaking.

2. Background

To understand the context in which digital agricultural extension services find themselves, this section considers the historical development of extension services in Kenya over time to illustrate the challenges it has faced and why they have been relatively unsuccessful. The basic features of the ICT sector in Kenya are also discussed to highlight why the country has become a hub for investment and initiatives as described in this thesis's introduction. The aspects of AIS and the way actors shape collaboration and interaction amongst themselves are as mentioned heavily ingrained in the context of the country, which requires some elaboration to situate the eventual findings of this paper.

2.1 Background of Agricultural Extension Services in Kenya

Kenyan extension services have evolved from largely government-driven approaches since independence to a greater plurality of actors in recent years. Public initiatives have generally focused broadly on food production, whilst parastatal organizations, cooperatives, and some out-grower companies have offered extension services towards specific commodities, mostly commercial crops like tea and coffee (Mukembo, 2015). Initial models for agricultural extension services were based on the triad of farmers' participation with extension workers and research institutions known as the farming systems research and extension model which lasted from 1965 until the early 1980s. Farms would be chosen to undergo trials for new techniques and crops based on their previous performance and the quality of the arability of the land they possessed (Nambiro and Omiti, 2007). It was hoped that the knowledge provided to these farmers would then spill over to other farmers (Okello et al, 2014). Except for the new form of hybrid maize that was introduced, this model was largely unsuccessful in improving smallholder agricultural productivity as the methods of incorporating farms into extension favored larger more affluent farmers, and the hope of knowledge dissemination was not realized as it failed to account for the diversity in agricultural landscapes and farmer attributes in Kenya (Nambiro and Omiti, 2007).

In light of its limitations, a new training and visit model to extension was incorporated in 1982 heavily supported by the World Bank, largely inspired by its success in India and Turkey (Davis and Place, 2003). As the name suggests, extension services were now predicated on equipping extension workers with the requisite knowledge and skills who would then frequent farms to pass

it on to farmers. The model continued with a top-down approach characterized by uniformity and inflexibility, meaning that the issues of the previous models to reach smallholders and provide them with relevant information continued. Extension of research was concentrated amongst specific crops, resulting in the information being irrelevant for smallholders who were growing other crops (Nambiro and Omiti, 2007). Remote and resource-poor farmers remained neglected whilst larger farms or smallholders in high-value plots benefited from available knowledge. The extension services implementation was generally ineffective due to poor management, a lack of funding, and generally under-skilled extension workers (Lopokoiyit et al, 2012). They would also be complemented by radio and television broadcasts but these were largely ineffective due to issues of coordinating their airing with farmers' activities as well as the information being irrelevant by the time it was aired (Okello et al, 2014). Training and visiting farm costs would be highlighted by the deteriorating economic landscape of the 1980s, where high oil prices and rising budget deficits would severely constrain governments' capacity to fund agricultural extension services (Davis and Place, 2003).

The failure of public extension services and growing international pressure toward liberalization saw them become increasingly privatized as Structural Adjustment Programs (SAPs) were introduced from the 1990s onwards (Lopokoiyit et al, 2012). This allowed for the private sector and civil society, namely NGOs, to begin to provide their agricultural extension services in the wake of a retreating public sector. Theoretically, increased diversity and the number of actors in the sector could contribute to increased competitiveness and sources of funding to not only reach more farmers but distribute resources more efficiently. Whilst the private sector may not be hindered by the bureaucratic delays associated with the public sectors and be more attuned to demand, as profit-seeking entities their extension services perpetuated outreach to larger and more commercially viable farms that had already disproportionately benefited in decades prior. This in part explains the emergence of NGOs in Kenyan agriculture, as their more holistic and not-for-profit approach, could be a more suitable substitute for the public sector in reaching poor and remote smallholder farmers (Muyanga and Jayne, 2008). The turn of the 2000s witnessed an eventual recognition of the importance of more participatory and demand-driven extension services, as outlined by the National Agricultural and Livestock Extension Program (NALEP) launched in 2000. Symbolic of this, Common Interest Groups (CIG) were formed where farmers active in similar activities were brought together to mediate their demands to extension officers from either the public sector or more commonly now civil society (Muthoni, 2018).

Extension services still struggle to not only reach farmers but also provide them with relevant information, arguably the increased competition brought by the private sector has in some ways impeded the broad diffusion of technologies in agriculture. NGOs are hampered by short-term and results-driven project designs limited in scope. Extension workers continue to be underequipped to handle the administrative and interpersonal dimensions associated with interacting with farmers

(Muyanga and Jane, 2008). The high ratio of farmers to personnel further constrains their capacity to provide individual farmers with relevant advice. Whilst it is hoped that ICT can help lessen the burden to an extent, the actual digital capabilities among both extension workers and farmers alike remain low (Muthoni, 2018). Whilst agricultural performance in Kenya has been stunted for various reasons, it can be said that the extension services up until now have largely failed to equip Kenyan smallholders with the adequate information and practices needed to improve their resilience towards external shocks. As digitalization enables more extension services to be provided, the ways these new and old actors collaborate and interact with each other as well as how well incorporated farmers are in this process will likely play a role in the efficacy digital extension services will have in lowering the overall vulnerability of the sector.

2.2 The ICT sector in Kenya

The ICT sector has grown substantially in Kenya since the early 2000s. Before this, ICT during the latter parts of the 20th century was generally neglected as it was feared it would undermine the political legitimacy of President Daniel Arap Moi's regime (1978 - 2002) by giving political opponents a platform. Skepticism towards computers and the like was a result of public sector fears that the technologies would reduce employment in the sector, so much so that the Kenyan government banned computers entirely in public offices in the 1980s (Ndemo and Weiss, 2017). As was the case with agriculture, the subsequent decade would be marked by increasing international and domestic pressure to liberalize the sector and open it up politically. Initial reforms under the Moi regime, such as the 1998 Kenya Communications Act, did distribute responsibility for the sector to several different institutions, yet remained politically closed. The 2002 election and resulting change in political power induced the first serious attempts at liberalizing the sector. 2004 would see the end of Telkom Kenya´s monopoly in the sector, which allowed other firms, notably Safaricom though initially a subsidiary of the former, to enter the market (Munyua, 2016). Substantial investment in ICT infrastructure would begin in 2009 with the first undersea internet cable, known as The East Africa Marine System (TEAMS), with a further five being built in the ensuing decade. The ICT sector in the first decade of 2000 had an annual growth rate of 20 percent (Baumuller, 2016).

The growth of ICT in Kenya was abetted by the rapidly declining prices of phones and the internet globally. The role of ICT would be highlighted in public vision through its various National Broadband Strategies (2013 and 2018) and more generally in its vision 2030. This desire was cemented by the 2013 Konza city project, built to develop an innovative hub for the sector. This environment has grown since 2010, such as ihub, Nailab, and the Nairobi garage which has benefited local startups in Kenya. International firms, like Nokia and Google, have also invested in the sector whilst IBM has established research labs to help develop ICT solutions (Akamanzi et al, 2016). Kenya's ICT infrastructure means that almost 96 percent of the country is covered by a

cellular network, and 77 percent of the country by a 4G mobile network (ITU, 2022). Internet penetration is at 90 percent (FAO and ITU, 2022). The diffusion of mobile phones has brought with it new economic opportunities, perhaps most notably the mobile banking service M-Pesa. Launched in 2007, it now has reportedly over 30 million users in Kenya (Guguyu, 2022). Phones are also the primary mechanism to access the internet and their usage has risen. Despite these successes, the ICT sector does experience several challenges. Lack of funding and a general disconnect between academic institutions and the associated labor demands of ICT leave firms lacking the required expertise. The focus of many small startups in Kenya is on attracting funding, usually from so-called 'Angel' investors, rather than consumer demand meaning that lots of technological solutions are not financially sustainable in the long run (Baumuller, 2016). Mobile phones are also not widespread, with only 47 percent of the population owning one in 2020, with phone sharing being common amongst households, and only 29 percent actively using the internet (ITU, 2022). Rural areas, in part due to lower access to electricity and lower population densities make extending networks in more remote areas costly.

The functions of ICT products, such as the mobile phone, allow the sector to act as complementary to other sectors of the economy, which hypothetically could allow for more efficient and sustainable use of resources by reducing associated transaction costs as well as disseminating information on a broader level. Considering the major obstacles faced by smallholder farmers in accessing inputs and finance as well as knowledge of market prices and overall crop management, mobile phone services, whether via text messaging or an application on a smartphone, have been leveraged as a digital solution (Deichmann et al., 2016). The poor performance of extension services and the agricultural sector over time amidst the emergence of a comparatively thriving ICT sector provides the context in which digital agricultural extension services operate. The increasing plurality of actors involved inherently creates new opportunities for networks and patterns of interaction to occur, yet whether they do and what characterizes this relationship is dependent on the prevailing attitudes that exist which are, as will be explored in this paper's theoretical framework, are often deeply ingrained and thus path dependent and not quick to change.

3. Theoretical Framework

As introduced in section 1, this thesis approaches the digital agricultural extension sector from an innovation system perspective. To reiterate, an AIS is viewed as the networks and interaction of actors involved in the sector, where their respective attitudes and practices shape the effectiveness and nature of these networks. This section begins with detailing the analytical insights AIS provides for understanding innovation within the sector, and the deeply contextual nature of the concept. Secondly, this paper articulates the innovations trajectory framework utilized and explains how it will be utilized to answer the research questions.

3.1 Analytical Insights of AIS

AIS recognizes that innovation does not only occur at the frontier but as a process in that actors interpret and interact with goods and services that are novel to them and include a diversity of actors. Consequently, innovation is more viewed in the application of knowledge rather than its production. To utilize inventions, innovation requires patterns of interaction between different stakeholders along not only the agricultural value chain but in sectors complementary to agriculture and the public sector. Ideally, this interactive process is inclusive in the sources and flows of knowledge, as a diversity of ideas allows innovation to be responsive to change. Underpinning the flow of information is the role of learning, which can occur both through the exchange of tacit or codified knowledge. The former refers to informal knowledge, which is usually embedded with existing practices strongly rooted in local cultural environments where learning often occurs through learning-by doing and imitations of the surroundings in contrast to the latter, which tends to be more explicitly understood and easily transferable between contexts as it is often written down and recorded (Hall et al. 2007).

Interactions are also guided by the nature of how different actors collaborate. There can be partnerships where some actors work towards a shared goal, but they can also be contracted to perform an activity on behalf of another organization for example. Linkages between actors allow knowledge to flow, and the presence and capacity of resulting networks are dependent on the attitudes of actors and their relationships with others, which is likely to differ with different actors, notably within and between the public and private sectors. Additionally, information is likely to be sticky. Ideally, knowledge flows should freely move across sources in a multilateral fashion, though in actuality it tends to be restricted as some actors may not have access to available networks or the sharing of information is poorly coordinated. The resulting lopsidedness of knowledge impedes the inclusivity and thus propensity to apply available knowledge into use (Hall et al. 2007).

The roles that actors partake in will likely change over time, and actors can encompass multiple roles at once, such as both being knowledge producer and coordinator. These evolving attitudes and practices of actors determine their tendency to innovate. Some have strong traditions in collaboration endowed by knowledge sharing whilst others may be self-isolated and be more risk averse and less trustful of their surroundings. Again, this will depend on the existing economic, cultural, and political context. As actors are understood as diverse in this regard, triggers for innovation, whether it be an emerging market or state incentive, will be responded to in different ways and thus outcomes will differ. This is important for the policies that form the enabling environment for innovation, and hypothetically reasonable policy may be ineffective if there is dissonance between its design and existing attitudes and practices (Hall et al. 2007).

AIS presents a holistic view of the interactions between a complex array of actors and recognizes the differences in actors and their attitudes as well as the institutional enabling environment that shapes how knowledge is applied in each context. This is especially relevant for the digital agricultural space, which is characterized by the growing inclusion of private actors and ICT technologies in agriculture, and this is certainly true of the Kenyan case. How knowledge flows between actors and their attitudes that facilitate or hinder collaboration will inevitably shape how impactful the social and economic outcomes are for smallholder farmers, and how inclusive the sector is to their demands (Hall et al. 2007). The wide scope of AIS is also somewhat of a limitation, in that to address as many aspects as it does it risks making some generalizations as to how actors tend to behave and interact with others, which may not be entirely accurate for any specific actor. However, this is somewhat unavoidable as it is practically impossible to include every actor when discussing the matter. The deeply contextual nature of AIS also precludes broader generalizations on digital agricultural services across space and time, though it should be noted that is also not the inherent goal of this thesis, rather the aim is to provide an example of how an innovation system underpinning digital agricultural services facilitates collaboration and interaction within and between different actors in Kenyan context (Klerkx et al. 2012).

3.2 Innovation Trajectories and Triggers

This thesis borrows the theoretical framework proposed by Hall et al. (2007) to assess the current state and features of the AIS that shape digital agricultural services' innovative capacity. The authors describe how the trigger for innovation can arise out of either existing market opportunities or be orchestrated by the public sector and both go through several developmental phases. Each phase indicates a progression toward what the authors consider a dynamic AIS, with each being characterized by several features concerning the prominent actors and their roles, their attitudes and practices and the accompanying patterns of interaction, and the institutional and policy environment that shape the above (Hall et al, 2006). A dynamic system is seen as one characterized by a diversity of actors that fulfill varying roles that are supported by coordinative bodies that support and identify issues that enable knowledge flows across the actors. Attitudes and practices are open to collaboration as there is an atmosphere of trust and inclusivity among all actors along the agricultural value chain and complementary sectors.

Their openness allows comprehensive networks to develop, where different means of interaction, like partnerships and contracting or even informal linkages are sustained. Actors are actively seeking new partners and collaborators, making the system adaptive and responsive to change. The enabling environment provides adequate resources to support and enhance the factors described above whilst creating incentives for entrepreneurial attitudes and enhancing and promoting further innovation in the system (Hall et al, 2007, p.99-100). The developmental phases are categorized

by either market-driven opportunities or public sector orchestration. The concept of phases is understood through an evolutionary perspective by the authors, in that it is possible to move in both directions as time passes, meaning that a dynamic innovation system may regress to earlier phases. This development over time is also heavily path-dependent, meaning that change is often an incremental process as existing characteristics may constrain the triggers for innovation (Hall et al., 2007).

The orchestrated innovation trajectory describes a case when the trigger of innovation resides in the public sector, and government initiatives are the main driving force behind developments in the innovation of the sector in question. The first phase is referred to as the pre-planned phase. At this stage, public and private actors whilst they may be present have not yet identified the opportunity and are more likely to be focused on traditional priorities. Accordingly, the linkages necessary to support interaction and knowledge sharing are not present. There is a strong division between public and private actors, and there is little trust between them. Patterns of interaction are likely to be basic and unidirectional, such as through extension agents to farmers and political lobbying. Poor access to information restricts the capacity to share knowledge. Similarly, whilst the public sector may be engaging in generic research, funding is absent as the opportunity remains to be identified at this point. The second stage, known as the foundation phase, is where the public sector has now identified the opportunity in the sector and begins exploring and initiating entrepreneurial activities, but linkages to other actors are yet to be established. Attitudes and practices remain unchanged, but the public sector is beginning to develop patterns of interaction within itself, and research into the sector is underway although its connection to demand is weak (Hall et al., 2007).

The third and final phase of the orchestrated trajectory is that of expansion. At this stage actors from both public and private society as well as civil society have different roles, clustered around research or enterprise, and there is an effective means to coordinate their actions, most likely supported by the government. The divide between public and private has begun to lessen, though it is likely to be fragile even at this point. The increasing linkages allow for actors to interact and for knowledge sharing to flow through public incentives often important in mobilizing these interactions, and their overall inclusivity of all stakeholders, such as farmers, may still be problematic. The enabling environment is in place with adequate funding for research and training but may still be lacking on a policy level to support entrepreneurship in the private sector. Nevertheless, the expansion phase is often characterized by numerous different projects, which provides an opportunity to ascertain which kind of arrangements will suit the local environment best and potentially lead to the emergence of a dynamic system of innovation (Hall et al., 2007).

The opposing trajectory is described as opportunity-driven meaning that it is led by primarily the private sector. The first phase, the nascent phase, is like the pre-planned phase described above in

the sense that the public sector has not identified or is effectively aware of an existing opportunity. Some producers, entrepreneurs, or NGOs however have recognized it, and their local connections and risk-taking behavior may lead to the formation of some new markets. Interaction occurs but normally at the local level, providing information on the materializing market but established networks are absent at this point. The enabling environment for the specific opportunity identified is non-existent at this point. The emergence phase that follows sees a sector become dominated by entrepreneurs who often rely on their local and informal ties to share and access knowledge and technology. The attitudes and practices in the private sector are centered on operationalizing this knowledge and competing in the market, whilst notions of inclusivity and environmental sustainability are prone to neglect at this stage. There is little trust in the public sector, which aside from limiting collaboration also means that regulations that may exist may not be closely followed or properly enforced. Patterns of interaction beyond local and informal networks are weak, and the poor connections between public and private sectors impede the production of relevant research as demand is not properly understood. The focus on competition within the sector may also distract private sector actors from further improving their products or service. Any linkages between the sectors are likely restricted to political lobbying. Policy support, whilst may have noticed the emerging opportunity, remains weak (Hall et al., 2007)

The third phase is the stagnation phase. The private sector has numerous well-established actors but is entrenched in their roles. Consequently, they are less receptive, and thus their capacity to adapt to new opportunities or mitigate existing challenges is constrained. The public sector at this point would be active in supporting the sector, yet the persistence of poor linkages with the private sector means it is usually ineffective in coordinating activities. Actors from civil society may have emerged in technology transfer roles, though they often fail to move beyond this role. Attitudes and practices in the private sector are focused on existing roles, whilst the public sector is more concerned with regulating the sector and isolated interventions to solve prevailing problems rather than identifying opportunities for further innovation. This is, like in the emergence phase, a result of poor connections between research organizations and demand. Networks remain underdeveloped, even if there are competitive forces incentivizing collaboration. The enabling environment is improved in this phase with more funding and research from the public sector directed to the sector yet as has been mentioned is not always aligned with the actual needs of the sector. This phase of stagnation is seen as common in the trajectory of many innovation systems. This large presence of private sector actors may create a competitive market, but also impede the collaboration and partnerships that are crucial in a dynamic innovation system (Hall et al., 2007).

What is notable about both trajectories is that the public sector regardless of whether they are the triggers for innovation or not as described above is fundamental to establishing a dynamic innovation system. Whilst the authors present the orchestrated trajectory as one of constant progression, where the second phase improves upon the first whilst the expansion phase similarly

ameliorates upon the second. An AIS triggered by market opportunities is seen as eventually stagnating without a prominent and effective public support system that can help coordinate and facilitate interaction in the sector. Civil society, whilst noted as a player at some phases of the AIS, is relatively understated and little attention is directed towards the sector. In the context of SSA and Kenya, international development agencies and NGOs often have a prominent role in the economy and as such will likely play an equally important role in the AIS. The notions of trust and attitudes of actors are also crucial in assessing an AIS, as the effectiveness of any intervention on behalf of the public sector would be undermined if the producers, entrepreneurs, or NGOs are skeptical about collaboration with them, to begin with. Thus, changes from one phase to the next are unlikely to be abrupt as shifting actors' perspectives on collaboration and building trust and openness is a slow and incremental process (Hall et al., 2007).

Considering the nature of and effectiveness of state involvement in the Kenyan agricultural and ICT sector as discussed in the background, digital extension services are both digitalization of services traditionally undertaken by the public sector whilst the ICT sector provides the applications and technologies that support them have been driven by the private sector and civil society. The AIS approach and framework described above allow for this research to evaluate how these diverse backgrounds shape how collaboration occurs and what kind of networks materialize. Patterns of interaction similarly are likely to be framed by heterogeneous characteristics of actors in the sector, and the differences in capabilities amongst them. The inclusivity of the sector and its incorporation of smallholder farmers in the development of digital services is also reliant on the features of the prevailing AIS that enable or hinder the flow of knowledge and its application across actors. The key role played by the public sector in the view of the framework also allows this paper to critically examine whether the roles that facilitate a dynamic innovation system are being fulfilled in Kenya, and by whom. This ultimately provides the opportunity to reflect on what needs to be done in the future to improve the socio-economic and environmental impacts of digital extension services.

4. Literature Review

Research on digitalization in Kenyan agriculture has generally focused on the opportunities and constraints to the adoption of mobile phones and relevant smartphone applications for smallholder farmers and their impact on yields. Innovation systems literature in Kenya has not approached the digital agricultural extension market specifically. This section aims to highlight the relevance of research on smallholder adoption for this study’s findings, and what conclusions have been drawn regarding the workings of the AIS in Kenya in previous literature. As will be shown, there is a need to assess how the various actors shape interaction and collaboration and the opportunities and issues it presents for the sector and small farmers specifically. Research thus far has investigated

innovation systems in ICT and agricultural sub-sectors independently rather than as a single unit of analysis, which is necessary given the complementary nature of ICT across economic sectors and its growing recognition as a tool for agricultural development as has been discussed throughout this thesis.

Marchant (2015) uses the case of Kenya to evaluate innovation in the country's ICT sector. She finds that Kenya's geopolitical history as a hub for international actors, in particular development aid, has endowed innovation in the sector with a transnational component. The nature of their activities has meant innovation is approached as a social good. They are a major source of funding and capital in the sector. Whilst they do support local entrepreneurs to establish their initiatives, Marchant argues a dependency on them for support leaves firms and start-ups vulnerable to changes in their priorities. Interaction is facilitated by the various local incubators, notably iHub, which allows entrepreneurs to meet industry representatives in a shared workspace mostly characterized by informal ties. The government, a crucial component in innovation as detailed in these papers' theoretical framework, was found to be lacking in the requisite skills and knowledge to participate in the sector and argued by Marchant to insufficiently engage with actors in the sector, and relevant legislation in intellectual property rights being underdeveloped and thus a constraint on innovation (Marchant, 2015).

Other innovation systems literature has generally operated through exploring subsectors in Kenyan agriculture. Hornum and Bolwig (2021) analyze the role of input suppliers in the AIS using the case of small-scale irrigation systems in Kenya. They frame their impact via three activities market creations for technological innovations, the creation, and diffusion of knowledge, and their influence on technology priorities. Input suppliers are found in addition to enhancing and adapting irrigation equipment and facilitating the respective supply chain, they are also active in providing advisory services and access to farm credit making them important vehicles for knowledge creation and transfer and thus key to enabling linkages to other actors in the AIS (Hornum and Bolwig, 2021). Kilelu et al (2011) also find that innovation intermediaries are crucial in supporting innovation, and identified 4 types of intermediaries operating in Kenyan agriculture: the technology broker, systemic broker, enterprise development, and input access support. The latter describes actors who operate in the smallholder context, to improve access to inputs and knowledge whilst minimizing the risk undertaken by small farmers, and whose commercial orientation relative to the other types is relatively limited due to the small financial margins associated with smallholder agriculture in Kenya

Odame et al (2009) look at the maize, tomato, and dairy sectors in Kenya and find that the main driver of innovation is the output market. The authors describe that whilst there were various linkages between a diverse array of actors, interactions with the public sector were weak due to a lack of trust on behalf of the private sector which results from the different modes of operation in

either sector according to the authors. The policy environment was viewed as mixed, as it often became bogged down by bureaucracy. It would be improved through greater harmonization between agricultural and environmental, land use, and policy (Odame et al, 2009). Another important aspect of AIS is its inclusivity. Kingiri (2014 and 2020) notes that ICT related extension services in Kenya were effective tools for smallholder farmers in areas where internet and literacy were accessible but were at risk of excluding those without access as well as potentially perpetuating gendered social norms and marginalizing women in agriculture further (Kingiri, 2014; 2020). Kilelu et al (2014) highlight the importance of the learning dynamics that shape smallholders' demands, and how related interests are not homogenous, in fact often in opposition with other actors' demands, which indubitably shapes the inclusivity of the AIS in Kenya (Kilelu et al, 2014).

There is extensive research on the impacts of digital information services on agriculture (see Klerkx et al, 2019) showing an association with higher input use, market integration, and household incomes amongst farmers. The focus of this thesis is not primarily on the direct impact of these services on productivity and incomes, but rather on the networks between actors and the interactions amongst them that influence the effectiveness of their delivery. The opportunities and challenges in their adoption and usage in Kenya highlighted by existing literature can be indicative of the issues present in the flow of knowledge and enabling environment of the overarching AIS. Tata and McNamara (2018) find that digital agricultural services allowed extension officers to reach a greater number of farmers than conventional in-person means of communicating with farmers, which as Amer et al (2018) note is convenient considering the mismatch in available officers to farmers. Ogutu et al (2013), Okello et al (2020), and Wawire et al (2017) find that gender, age, and education are significant determinants of the service's eventual usage.

As aforementioned these mobile services remain underutilized by small-scale Kenyan farmers. Wyche and Steinfield (2016) and Kieti et al. (2022) note that the design of many of these services is often not aligned with the capabilities and demands of many farmers. Both note the steep learning curve to utilize both smartphones and basic mobile phones are often time-consuming, and often discourages use amid the laborious nature of agricultural work. This is especially true for women, who in general have less access to capital and education in relation to men. More generally in rural Kenya mobile phones are more associated with social activities as opposed to a source of information, pointing to Kieti et al.'s insight that awareness of available services is low in part due to a lack of advertising channels for these services. As corroborated by Gichamba et al (2017) this is indicative of poor linkages and partnerships in the sector, whereby farmers are not adequately involved in the development of these services. Wyche and Steinfield argue that the preference for voice calls, which are seen as more reliable than SMS services, makes many of the SMS services available less attractive for farmers to use. Besides its relatively costly nature, texting on basic mobile phones is an arduous task for farmers due to low literacy rates, language barriers, and the

often-dire state of mobile phones used, often because of extended use and accidents resulting in cracked screens and exposure to the elements. Lack of electricity to charge their mobile phones also means that they are left at charging kiosks, which are often quite a distance away from the farm itself, meaning that SMS as a constant source of information is rarely used in such a manner.

Kieti et al also note that the information provided tends to not be specifically targeted for each farmer's needs and that the overall experience in utilizing the service is fraught with technical difficulties[1], and means that the risk to reward of utilizing SMS services is high due to its relatively costly nature. Krell et al (2021) note that many of the digital services are also based on smartphone technology, which inevitably excludes most smallholder farmers from using them. The emerging presence of smartphones and SMS services also in some ways is seen as undermining their use as the numerous digital services available with minor differences in available information have the potential to overwhelm farmers, and as Awuor et al. (2016) argue, there is a need for more effective coordination in the sector and collaboration amongst all stakeholders, particularly in the creation of single information access point to simplify and streamline the process to access relevant services for smallholder farmers. Lamm et al. (2020) find that the lack of coordination between extension providers means that farmers receive often conflicting information from different services and the associated effort and cost are often duplicated due to the absence of shared knowledge. Resources are therefore not being used efficiently hampering gains in agricultural productivity.

There is a consensus amongst the literature considered here that the Kenyan government could be doing more to support the sector, particularly in facilitating the dissemination of knowledge from research institutions to farmers and financing (Amer et al, 2018; Kieti et al, 2022; Tata and McNamara, 2018, etc.). Makini et al (2020) review the status of ICT services in Kenyan agriculture and find that whilst the government in broader terms recognizes the potential for digital services for national and sectoral policy, there is an absence of a distinctive policy for Kenyan agriculture. The enabling environment as has been discussed throughout this thesis attracted significant attention and investment and has led to a burgeoning increase in available services, yet the sector in Makini et al view remains in the early stages of growth. The Kenyan government should provide more incentives for the private sector to broaden its digital services, and support efforts to raise digital literacy amongst farmers. The authors note the lack of a legal and regulatory framework as well as a harmonized model for financing as notable hindrances to the sector's growth (Makini et al, 2020).

The findings of the previous literature presented above will likely have implications for this thesis. The thesis builds upon them and contributes to the field by examining how the existing networks and forms of interaction are shaped, and exploring why linkages between different actors, such as

[1] A common example of this is receiving responses stating that there is no available information concerning a request made by a farmer (Wyche and Steinfield, 2016).

those toward and from farmers and between the private and public sectors have had difficulties in arising and enabling knowledge sharing in the digital agriculture extension service sector. The AIS perspective allows for many of the problems identified by previous studies to be integrated and for the connections between issues of coordination and knowledge flows to be articulated and discussed, an aspect which previous literature has not performed to this point. The holistic approach taken by this thesis allows for the heterogeneity in the sector to be brought to the foreground to understand how actors operating with differing resources and capabilities interact and compromise, how networks and collaboration are sustained, and how perceptions of actors to others limit and constrain their activities.

5. Methodology

To explore the AIS underlying digital extension services in Kenya, this thesis adopts a qualitative case study approach as these aspects are inherently difficult to quantify. The intent is to allow for the data that is collected and subsequently analyzed to not only be representative of the diversity in terms of actors that exist within the sector to be magnified but allow for it to be embedded in the socio-economic context of the country. This serves to endow this thesis's research with both an intrinsic and instrumental purpose. The former, referring to a case that is considered unique, is achieved by highlighting the case of Kenya which as aforementioned has become an international hub in SSA for ICT generally, and has thus been home to a plethora of digital initiatives in agriculture making it worthwhile to investigate due to this concentration. Secondly, it is instrumental in the way patterns of collaboration, interaction and the respective attitudes of actors can provide insight as to how digital initiatives can hamper or promote the desired social and environmental impact needed to meet the SDGs in a developing context like that of Kenya (Punch, 2013). To reiterate, this thesis asks the following research questions.

1. How do the different actors involved in digital agricultural extension services in Kenya shape collaboration and interaction amongst each other?
2. How supportive has the Kenyan public sector been of digital extension services?
3. How do the factors above reflect the trajectory of innovation in the sector?

To answer these questions five in-depth interviews were conducted, 4 of which were with individuals who represented digital service providers in Kenya, the other being an expert interview. For the sake of anonymity, the respondents are cited with a letter from “A” to “E” for their privacy. The in-depth interviews consist of open-ended questions with the intent to promote conversation and allow for the participants to articulate and conceptualize their thoughts and thus reveal their insights as to how their respective organizations operate, collaborate, and interact with others in developing and implementing their respective digital extension services. The interviews were

accompanied by an interview guide based on this paper's theoretical framework to mitigate the possibility of participants being sidetracked during the interview, and ensuing initial questions follow up questions were asked on a case-by-case basis, and therefore did not receive the interview questions on advance (Curtis and Curtis, 2011). This guide consisted of questions regarding the origins of the project in question, the opportunities, and challenges to collaboration with different stakeholders such as international organizations or the public sector, their interaction with them and with smallholder farmers, and their views on the public sector (Punch, 2013).

The exact interview structure was therefore not uniform across all the interviews. Participants were identified through purposive sampling to ensure they possessed the experience and knowledge in the field to properly assess and answer the questions posed to them (Punch, 2013). This thesis approaches the data from a social realist perspective, meaning that the response from participants is viewed as being representative of at least some of the realities in the sector. The interview process was in this sense for this knowledge to be articulated and reflected upon (Curtis and Curtis, 2011). The interviews were recorded with the participant's consent and later transcribed to enable an analysis of the collected data. Data analysis is built upon the Miles and Huberman framework built upon data reduction, display, and the associated drawing and verification of conclusions. Reducing data refers to the process of identifying and summarizing the information collected. Data display is the process of visualizing data to support the findings of the paper. Lastly, drawing conclusions from the data establishes the relevance and relationships the data has regarding the aims of this thesis and the associated theoretical framework (Punch, 2013).

The analysis is guided by a coding scheme to improve its internal validity and analytical consistency. Coding refers specifically to labels and concepts that are used to categorize and conceptualize the collected data. Both descriptive and inferential codes were utilized. The former refers to the basic categorization and summarization of the data whilst the latter refers to the identification of underlying patterns and themes that connect the descriptive codes, involving a process of abstraction as the underlying meaning and ideas are associated with the theoretical underpinnings of this research as discussed in Section 3 (Punch, 2013). The specific coding scheme used by this thesis can be understood as a two-step process. The first step, which can be referred to as the descriptive phase, involves associating and identifying statements that indicate a participant's attitudes towards collaboration, interaction, and the underlying enabling environment within the Kenyan digital agricultural sector in providing digital extension services. The inferential phase, the 2nd step of the coding scheme, then associates the codes from the first phase with the different triggers and phases of development of AIS described, for instance, if they are associated with the nascent stage of the opportunity-driven trajectory or reflective of an orchestrated trajectory. This process is visualized in Table 1.

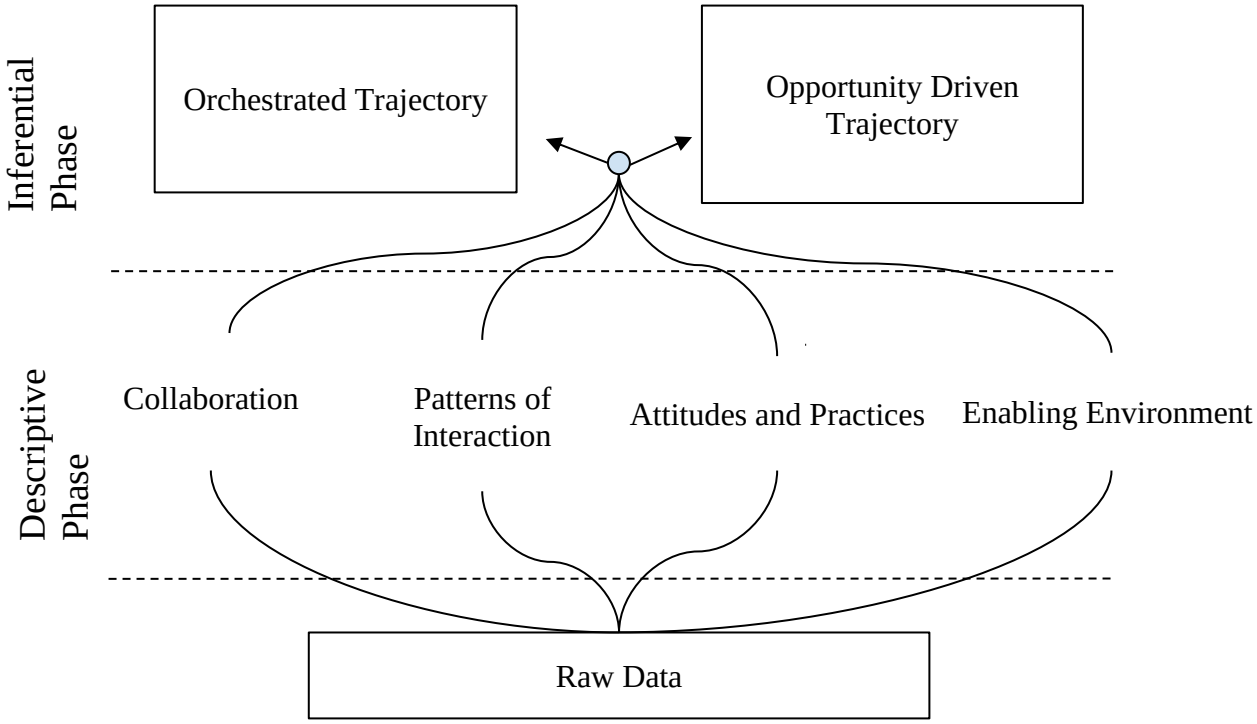

Table 1. Coding Scheme

5.1 Limitations

The major limitation of qualitative case studies and collecting data through in-depth interviews is its lack of generalizability. The context-dependent nature of highlighting actors' perspectives and attitudes towards other actors implies that the conclusions of this research may not be applicable elsewhere. However, it is also not the intent of this research either to be generalizable, as exploring a singular case in depth has its value, and attempting to extrapolate the findings would not be inappropriate in what is an inherently diverse array of actors involved in different countries with heterogeneous economic and sociopolitical landscapes (Punch, 2013). Another limitation inherent specifically to the interview process is the issue of bias from both the interviewer and participant. It is recognized that the latter may for one reason, or another be not honest in their responses. Consequently, previous literature and other interview data will be considered as a means of validating individual statements. Interviewer bias, also known as reflexivity, refers to the implicit notion that research will to some extent be interpreted from the researcher's own academic and personal background making it difficult to approach data from a completely objective standpoint.

The use of an interview guide and the coding scheme described can be seen as a mechanism for mitigating this bias, but this research acknowledges that some bias may remain (Gibbs, 2018). Lastly, the data collected by this thesis does not directly include an actor from the public sector, skewing the sample data towards actors from private and civil society. This means that the findings concerning the public sector are based on the perspectives and experiences of other actors, which is a limitation in holistically representing the AIS. Nevertheless, the social realist approach assumes that even if the data is not directly representative of the public sector, the views expressed will still be valuable in reflecting the realities of the sector more generally.

6. Analysis and Discussion

6.1 Features of the AIS of Digital Agricultural Extension Services in Kenya

6.1.1 Facilitators of Collaboration

Many of the digital extension services in Kenya operate within the private sector and are in one way or another linked with civil society, which as discussed has been dominated by international development agencies and NGOs, who participate in the sector through either funding, collaborating with or directly providing these services as indicated by collected data arguing that the "huge proliferation of apps in Kenya which come through NGO activity, (...)" (B, Interview). What is notable is their involvement in the way collaboration, a vital component of any AIS, is shaped and depends on these actors to occur. In line with the growing international paradigm of participatory development, many of these organizations make a deliberate effort to involve Kenyan partners as was noted by one respondent who stated.

"They (NGOs) have a policy of also working with you know, a Dutch organization plus a local organization, so they are into partnerships".

"… NGOs have also tried to bring partners together to collaborate. But it still seems a long way forward" (A, Interview).

Implied by the above is that not only are NGOs active in instigating interaction with and between stakeholders but are not entirely successful in this regard for reasons both internal and external to them. To show the differences in the kind of partnerships that are enabled on the international level in contrast to that of Kenya, consider the case of the "Cropmon" project (Crop Monitoring Service). The project was characterized by public and private partnerships as well as a further transnational

aspect beyond its implementation in Kenya. These networks of organizations from the civil, private, and public sectors are indicative of established attitudes and practices that enable such networks to form, which is relevant when considering the context of Kenya where these types of collaborations, particularly those between public and private sector actors are fewer in number and less intricate in comparison. As will be elaborated further the enabling environment of digital extension services in Kenya based on this thesis's findings and corroborated by previous studies, does not seem to support this level of complexity amongst different providers. Interactions between international development organizations and Kenyan digital services tend to reflect the role described in the Cropmon project, whereby Kenyan organizations and other digital extension services are contracted to help achieve outcomes of a project designed internationally.

Along these lines, it has been noted during the interviews conducted that some local actors have "...been given the impression sometimes with the development organizations that, as an innovator, you're just seen as a service provider" (B, Interview). This shapes the nature of the interaction between local and international actors where the former competes amongst themselves to attract funding from the latter, a process in which one respondent summarized as "I always considered myself a prostitute. Whoever pays me I can do a trick!" (D, Interview). Whilst the international funding certainly has a part to play in contexts like Kenya with comparative deficits in terms of capital, the sentiment expressed above indicates that the capacity to make demands and to align interests involves certain compromises to the priorities of development organizations. This is not an inherent critique, as financial donors are entitled to set the terms of cooperation, yet it highlights the inherent power dynamics that shape the way collaboration tends to be organized, whereby receivers of funds are in a sense subservient to the priorities of international donors.

This thesis also finds that this relationship has a perverse impact on how collaboration is facilitated and sustained in the long term. As was noted by Marchant (2015), the motivation for producing a social impact has been a major justification for their involvement in Kenya over time. Other issues previous literature identified such as their unrealistic timebound projects, the push towards quantifiable outcomes for evaluation, and overall neglect of the long-term financial sustainability of funded initiatives and NGO projects were affirmed by this thesis. One noted that the focus was "(...)too much on only the technical sides, and not too much on making a business out of it." (E, Interview). This was affirmed by another respondent who added "I don't think the NGOs and (...) this donor organizations are doing well in terms of in terms of asking the questions of (financial) sustainability to these organizations (Kenyan Digital Extension Services) (A, Interview)".

The findings of this thesis contribute to the existing literature by highlighting how collaboration and the networks that facilitate them mirror this process. What this means is that collaboration is rarely sustained after a project's end, which was noted by one respondent who said "There are projects that are within consortiums that tried to bring in different partners to work together. But

it doesn't seem to go further than the period of the projects that are there for some reason." (A, Interview). In this sense, we can see that the main facilitator of collaboration is the funding associated with these projects, which consequently follows its cyclical nature. If an NGO wanted to continue a project past its official funding period, it was observed that enticing partners with whom they had already collaborated with difficult to entice a second time around with less funding. This was exemplified by one respondent who noted "(...) we wanted to continue the services (but for) that we then need some money to cover our costs. And that was very difficult. And, partners saying, 'Yeah, we want to cooperate, we want to continue, but then at the end, yeah, there's nothing so that." (E, Interview). This is not to say cooperation was entirely smooth during the project either. As mentioned below, differences in working culture between the Dutch and Kenyan partners involved in the project slowed the overall process.

"(...) And the culture is also different. So, if we ask something to a Dutch partner, then we get a reply in a few days. But sometimes when with the Kenyan partners, it takes longer. (....) That's why it's always a bit more challenging working with the Kenyan partner". (E, Interview).

This was also a tendency for funding to be directed to new initiatives within the digital extension which has endowed the sector with "many small players solving one or two challenges, i.e., one on financing, another on market information, another for inputs, etc." (A, Interview) or as another put it a "(...) left with an app store that is full of full of applications, but you can't really use them, because there is no (financial) sustainability that is around" (B, Interview). As shown by the above quotes, the sector is highly fragmented and indicative of a lack of coordination between actors within the sector. The efforts and costs associated with the acquisition of farmers are often duplicated which results in substantial inefficiencies in the sector. For farmers there is little incentive for them to invest long-term into these services, contributing to the lack of financial sustainability in the sector. It is already the case that profit margins are going to be small due to the low purchasing power of small farmers in Kenya, and that as a result they are inherently risk averse as found by previous studies. Considering these attributes, digital services are generally free to use to be competitive in the sector and have the desired social impact in the sector. But due to the cyclical nature of many donors funded projects, farmers are increasingly cognizant of the fact that they need only wait for a new project to arise where they can continue to receive similar services at no cost which makes enticing them to commit financially to a service long term difficult. Attempting to shift away from the free model is difficult, and as one respondent put it "then we say now you need to pay, they (farmers) say why? It was always free, so I can better stop now and quit the service and next year there's again a donor-funded project where I can get served for free" (E, Interview).

The fragmented nature of a plethora of digital extension services that are often occupied specifically with one aspect of the multiple information needs of smallholder farmers in Kenya has

also created what one respondent referred to as a "digital confusion". The duplication of efforts and costs creates fatigue amongst farmers who are constantly asked to register for new services, and the constant turnover inhibits the building of trust between farmers and digital extension providers. The abundance of services also complicates the eventual decision-making process for farmers as one respondent put it "this fragmented approach, basically just makes it very difficult for a farmer who is now exposed to all these digital tools to make a decision and make the right decision" (B, Interview). These findings affirm conclusions made by previous studies on the need to better coordinate investment in the sector, and even direct funding towards "strengthening already existing service providers, and not duplicating what is already in the space in the name of innovation" (C, Interview).

Yet this is easier said this done, and as was mentioned by one respondent, “there has to be a clear pathway for cooperation.” (D, Interview). As many of the Kenyan digital extension providers are from the private sector, there exists a delicate balance between the need to establish themselves in the field to be competitive and the need to coordinate their activities with others, a balance which seems tipped towards the former as noted by one respondent who stated "they (private sector) are looking at their own piece of the puzzle." (A, Interview), who also posed the pertinent question “How do we share in, you know, share in the losses and the profits?” (A, Interview). Competition certainly has its place, but as another respondent pointed out “competition should be based on the different services that are being provided, let's compete at that point, but not amongst each other to fragment the market even more” (B, Interview).

6.1.2 The Perceived Role of the Kenyan Public Sector

Considering the idiosyncrasies of collaboration amongst and between the private sector and civil society in Kenya, particularly in coordinating their activities, the role of the public sector is a vital aspect of a functioning AIS. As previously mentioned, however, this thesis was unable to include a relevant actor from the public sector. The conclusions do not represent the public sector directly, and as such the way the public sector views other actors is difficult to infer. Accordingly, the findings can be interpreted as the perceived role of the public sector. As argued in section 5.1, these perceptions are still presumed to reflect the role of the public sector to some extent and as such will still have implications for the functioning of the AIS, and its phase of trajectory. To begin, trust between the private sector and the public sector in the case of Kenya seems to be missing. Most of those interviewed indicated that on a more general and infrastructural level the government has been relatively supportive as seen in the growing penetration of mobile and internet connectivity and investment in undersea internet cables. One noted the "data privacy act, that came into place, which has enabled us in the digital space” (B, Interview), and another said that they "didn't have issues with regulations or other things" (E, Interview). It should be noted

that this view was not universal across the collected data, with one noting that “the scope of work between partners can be limited to due to policy issues” (C, Interview). Yet when the discussion shifted towards the public sector's direct involvement in digital agricultural extension services, the views expressed indicated a sentiment that the sector could be doing a lot more than what was being done.

The public sector was described as passive at best with one response describing that a more proactive government could use their resources " (...) to register farmers all over the country, and then I, who is a player does not have to come and do the work again (...) and you have reduced the cost of acquisition" (A, Interview) which in his view would help reduce the aforementioned fragmentation by providing “a platform of which people can come together and collaborate”(A, Interview). Yet even despite this apparent gap in and demand for more coordination of the Kenyan digital extension services, the enduring lack of trust between the private and public sectors makes realizing this difficult. The private and public sectors were described as deliberately “trying to avoid with each other” (A, Interview). Collaboration was weighed down by lengthy bureaucratic processes which were not seen as worthwhile for the private sector, who would therefore prefer to “do it themselves”. This sentiment is reinforced due to the “many loopholes for corruption” that endow the public sector (A, Interview). One respondent noted that they were forced to pull out of a public partnership as “they were taking too much money out of that funding and not leaving enough for us to do a good job.” (D, Interview). Another described the attitude of the public sector as self-serving by impersonating public officials and stating that “it has to benefit me (the public sector) individually for me to work with it.” (B, Interview).

Additionally, public sector actors were described as lacking digital knowhow, with one respondent expressing the desire to “(...) train all those guys (being those working in the public sector) on how to use digital information” (D, Interview) and another described the Kenyan Agriculture and Livestock Organization (KALRO), a public organization that has been active in launching digital extension services, as not being very “tech-savvy” (A, Interview). The Agricultural Sector Transformation and Growth Strategy (ASTGS) report published by the Ministry of Agriculture, Livestock, Fisheries, and Irrigation (MOALFI) (2019) in Kenya recognized the potential for the public sector to play a vital role in the sector observing that;

> Successful digital solutions address both digital and non-digital barriers to scale. Government has an important role to play in this ecosystem, particularly in solutions that operate like public goods by investing in middleware (e.g., farmer registers – including livestock and digital agronomy data), and accelerating implementation of forward-looking data policies (e.g., data privacy, drone commercialization). This work focuses on digital interventions that the government is well placed to champion and drive, not solutions that the private sector and other players can implement successfully

Themselves (MOALFI, 2019, p.4).

There are several other examples of public sector strategy documents and vision statements that recognize the public sector roles in digital agriculture, yet as noted by Osiemo et al (2021) and affirmed by this thesis, it has not materialized yet into tangible policy interventions or support for the sector. There have been isolated interventions on behalf of the Kenyan government to provide their digital extension services, yet they were often ineffective due to reasons discussed above, such as bureaucratic delays and poor digital capabilities. As one respondent put it; "they have guided in terms of regulatory approach, on the other hand, everything they try to do just keeps failing" and that their involvement "messes up the whole equation, because you need a policy group that is enabling you to have the right laws and regulations to streamline activities in the ecosystem, but they keep their hands out of the business themselves" (B, Interview). This response further highlights the underlying skepticism of the public sector from private actors, though it is not the place of this thesis to determine if it is warranted but rather to reveal the underlying attitudes that shape their collaboration, or lack thereof, in the sector. Whilst one actor noted that the public sector had begun to better inform them of existing policy within extension services in Kenya, they noted the desire to "(...) see more is a deliberate effort by the government, to involve the private sector more in their implementation of their policies and their government projects" (C, Interview).

6.1.3 Actors, Practices, and Interactions with Smallholder farmers

Whilst smallholder farmers are inherently diverse, the key decision makers on the farm can be effectively summarized as “relatively old and not the strongest learners” (D, Interview) but generally are the ones with “land ownership, (...) and who make very key decisions in terms of what to produce and when to produce.” (C, Interview). Questions of land ownership, and the issues they pose in Kenya, are beyond the scope of this thesis. What is important is the way these key farmers shape the ways information is articulated and shared by extension service providers. As noted by one respondent "farmers (...) are used to doing things a traditional way in a way (...) they would always plant the same date every year because that's just how they have been doing it to their family." (B, Interview). Therefore, building trust for digital services requires providers to accommodate the limited digital literacy most farmers have. The success of M-Pesa in this regard has gone some ways to establishing that mobile phones can be a source of relevant information besides solely access to finance which has progressively “changed their attitude and behavior towards digital communication” (C, Interview). Though many services are geared towards basic feature phones through SMS, smartphones are both not widespread in Kenyan agriculture and involve a greater degree of digital competency for them to be effective.

Whilst digital extension services could reduce transaction costs normally associated with conventional approaches as well as be more time efficient, the data collected highlights the

continuing importance of in-person interactions. As mentioned in the background of this thesis, previous iterations of extension services in Kenya have suffered from a lack of understanding of farmers' actual needs and demands, which in the proliferation of digital extension services described above has continued, with one respondent arguing that most "(...) do not have a human-centered approach to the development of the solution" and that they have not " (...) gone out there to the farmer to ask, what is the usability and you know stay there with a farmer, or whoever is interacting with the system just to see the if it works." (A, Interview). This is indicative of an AIS in which the inclusion of all stakeholders' interests remains constrained in the development and implementation of digital services.

One respondent observed that many of the NGOs neglect the "minor details" involved in interacting with and disseminating services amongst farmers (C, Interview). Whilst they may be successful in raising awareness and changing perceptions, there is also a tendency to miss the fact that the "actual practice of it is probably is hindered by finance or some people just survive, (and) this was not the right time for them to implement this" (C, Interview). This is indicative of a lack of awareness on behalf of NGOs towards the constraints on utilizing provided information. Inclusivity is dependent on the language used which was noted by this study's literature review and affirmed here, as noted in one instance that multiple languages were "not implemented because there was too much discussion between Kenyan partners on how to translate the message" (E, Interview).

Conventional approaches to interacting with farmers, such as working through farmer groups, cooperatives, and the like remain a useful avenue for digital extension services, as is the reliance on community leaders who can help build digital capacities in their communities. In this sense, digital services have redefined the responsibilities of contemporary facilitators of agricultural extension to include the knowledge needed to utilize and interpret information received digitally. Considering the typical profile of the key decision makers as older farmers, digitalization has also enabled the incorporation of younger demographics who are comparatively more digitally able in respect to the average farmer. An example of this would be Yielder Ambassadors Network (YAN) which targets young and agriculturally educated Kenyans, who would normally struggle to work in the field due to the poor linkages between academia and the sector, to have an active role in the sector as private extension agents, combatting the "knowledge leakage" present in the economy. The focus on youth provides an opportunity for broader participation in agriculture by those who normally are excluded due to the issues in land ownership in Kenya, an act that is generally seen as "culturally strange" in the country. YAN also opens the ability for blended models for extension, meaning that classic in-person training is combined and hopefully enhanced by digital media to instruct farmers in different ways, which showcases how digital extension services can enhance conventional approaches without entirely replacing them.

Digital extension services, at least in well-functioning environments, have the potential to merge a lot of roles along the agricultural value chain into one, such as those performed by intermediaries or middlemen. Through digitalization "(...) you make them actually visible. And you make it clear to everyone who do I believe in and who do I not." (B, Interview). Yet, as noted by previous literature, for this to be realized digital extension services alone are not enough as the reasons why farmers depend on intermediaries to the extent that they do is not solely due to a lack of information on actual market prices, but due to infrastructural and geographical obstacles in accessing markets in addition to their underlying interpersonal relationships with the middlemen themselves. To summarize, the findings of this thesis would suggest that whilst digitalization has brought new dimensions to the attributes of service providers and users, as exemplified by the YAN. Digital extension services can be seen as more as redefining the responsibilities associated with agricultural extension services rather than a replacement of conventional practices. This section also highlights how some traditional issues that have hampered extension services have persisted despite increased digitalization.

6.2 The Innovation Trajectory of Digital Extension Services

Considering the features of the AIS of digital agricultural extension services in Kenya, this section now contemplates how they relate to the different innovation trajectories and phases described in the theoretical framework of this thesis. Out of the 2 innovation triggers, the findings suggest, and as was indicated in the discussion of the ICT sector in general, that it has been led primarily by the private sector and civil society in an opportunity-driven trajectory. The public sector has been more focused on supporting the general infrastructure of ICT and has played a more passive role in supporting digital agricultural extension services specifically. Consequently, many of the providers are from the private sector or civil society. Their abundance and the issues it poses for collaboration and interaction are indicative of the stagnation phase. The highly fragmented nature of the sector and narrow scope of many of the "small players" and difficulty in achieving financial sustainability means that their capacity to adapt to their roles is limited as they have become entrenched in their roles, and the lack of coordination in the sector has resulted in inefficiencies in the overall allocation of resources.

The theoretical framework posited the facilitatory role of civil society, being the international development agencies and NGOs, in relation to technology transfer roles but this paper finds that they operate on a broader scale in Kenya. As discussed, they are very active in collaborating and framing patterns of interaction. However, as suggested by the theoretical framework, these activities are not always well synchronized with the needs and attributes of smallholder farmers which have been neglected. The knowledge flows between stakeholders remain generally

unilateral despite stated participatory rhetoric from many of the international NGOs. Activity from the public sector in the sector has generally been observed in isolated interventions. Roles associated with coordination in the sector have yet to be properly addressed by any actor in the sector despite their importance being widely recognized as shown by this paper's findings. Whilst there is likely a myriad of reasons for this that are beyond the scope of this thesis, the findings presented in the previous section indicate the lack of trust between the private sector and public sector is a key factor. The copious amount of digital extension services also presents difficulty allowing for collaboration to form, as the competition has thus far driven the sector towards further fragmentation. It is not meant that competition within the private sector is inherently bad, but in the absence of proper coordination, which may arguably be an avenue for the public sector to direct its attention towards, the benefits it provides for an economy are not properly realized.

7. Conclusion

The capacity for digital extension services to provide smallholder farmers with the information they need to improve their productivity and resilience to external shocks whilst doing so in a sustainable manner depends on the functioning of the underlying AIS. In the case of Kenya, this thesis finds that the AIS does not yet constitute a dynamic system as depicted by the theoretical framework. Instead, the current landscape resembles that of the stagnation phase of the opportunity-driven trajectory. The development of digital services has been driven by both the private sector and civil society, whilst the Kenyan public sector beyond investment in the infrastructure that facilitates ICT use in the country has been observed to not provide the enabling environment it is associated within a dynamic AIS. Civil society and especially international development agencies and NGOs have undertaken some of these responsibilities, particularly regarding the provision of funding and research for the sector itself. This thesis affirms many of the criticisms that have been levied against their involvement in the past, namely the short-sighted and quantifiable nature of project design and implementation, the cyclical character of its priorities, and the dependence on the resources it incites within local service providers.

The findings contribute to the existing literature by highlighting how these shortcomings impact how partners collaborate and interact. As most funds have gone towards funding new digital initiatives rather than enhancing existing ones, there has been an explosion of digital extension services which has left the sector heavily saturated but poorly coordinated. The emphasis on creating a social impact has generally neglected the financial sustainability of these proposed solutions, which means that many of them are not sustained in the long term when donor money runs out. International NGOs and development agencies are key facilitators of collaboration in the sector, which again means that once a project officially finishes, the networks the project supported also fall apart. The constant turnover of projects and services creates little trust between smallholder farmers and digital extension services and provides little to no incentive for them to

deviate from their typical risk-averse tendencies. The superfluous number of services and lack of coordination also create significant inefficiencies in how resources are allocated, resulting in the duplication of money and time involved in registering and servicing farmers. From the perspective of farmers, it creates a “digital confusion”, whereby the amount of information available and constant need to re-register not only undermines their capacity to obtain relevant information for their needs but also becomes a source of fatigue.

There is a need to better coordinate digital extension services in Kenya, yet the existing attitudes towards collaboration amongst Kenyan actors have thus far not been supportive due in part to the dilemma the private sector faces because of competitive market dynamics and tight profit margins, and more significantly the lack of trust between the private sector and public sector. This means that even despite its widespread recognition of the value of collaboration, it has not materialized into anything substantive. As such, the enabling environment afforded by the public sector has been passive at best, in the sense that it has not directly intervened to hinder the development of private sector digital agricultural extension services but has arguably not fulfilled the role anticipated by this thesis's theoretical framework. Interactions between international donors, NGOs and extension services, and smallholder farmers remain largely stratified, resulting in projects and services not attuned to the real demands of farmers, hampering the inclusivity of the AIS.

The importance of in-person relations remains critical to building trust across parties, an aspect this thesis has found to be largely neglected in the development of digital extension services. However, digitalization also poses promise as to how conventional in-person extension services can be complemented, as was seen in the use of blended learning models to interact with smallholder farmers. In this sense, digital extension services may not have the transformative impact of replacing traditional extension services, but rather redefine what is expected of the role. The Digital capabilities required to disseminate information present opportunities for the more digitally capable young population in Kenya to be active in agriculture, where key decisions traditionally are made by the older population, who are comparatively less digitally literate. Lastly, despite suggestions that digitalization will help cut out the middlemen and lower overall transaction costs in the sector, the relationships between them and farmers are inherently complex, and thus it is perhaps too early for any conclusions to be drawn as to the actual impact digital agricultural extension services will have on their roles.

7.1 Policy Implications and Areas for Future Research

The findings of this paper have several implications for public policy in the Kenyan digital agricultural scene as well as for international donors, NGOs, and other private sector providers.

The public and private sectors must overcome the lack of trust that exists between them, and there is certainly a gap for an actor to fulfill in coordinating the sector, and the public sector by its admission recognizes as one it can contribute towards. Greater cooperation between the sectors would serve to improve service delivery and allocate resources more effectively. Additionally, there is a need for the public sector to develop a more comprehensive legal and regulatory framework for the sector. International donors and NGOs, considering the saturated and fragmented nature of the sector, may be better served to enhance existing digital services as opposed to implementing their projects directly or funding new services. Additionally, there should be a greater emphasis on the long-term financial sustainability of the digital services provided and a greater attunement towards the demands and needs of farmers and their digital capacities.

Combining digital services with conventional in-person interaction, as argued by this thesis, could serve to enhance and efficacy of extension services in agriculture. Future research is needed in this respect to better understand the impact digital extension services have on learning as well the tangible effects on productivity and environmental sustainability. Building on the contributions of this thesis, research should aim to include a broader range of actors, particularly those representing the public sector directly and smallholder farmers to build a more holistic image of the AIS than the one depicted here. Another aspect that deserves further attention is how digitalization will transform traditional agricultural roles, particularly that of intermediaries, in the long term and how developing countries deal with the social implications that these shifts may have.

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