

Creating Responsible Innovation in sub-Saharan Africa's Digital Agricultural
A Case Study Approach

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ABSTRACT

This paper aims to contribute to the ongoing conceptual debate on Responsible Innovation, and its application to the smallholder farmer context in sub-Saharan Africa. Currently the continent is facing stagnant growth within its agricultural sector. Advanced digital technologies such as smart farming and precision agriculture are being pushed as the fix-all solution to stimulating growth. However, little attention has been paid to its appropriateness or the potential socio-ethical impact such technology might bring to the sector and smallholder farming communities. Therefore, this study set out to answer the following research question: How do agricultural organisations create responsible innovation using digital media within the farming sector in sub-Saharan Africa? Based on a qualitative case study of the hybrid seed developer, East-West Seed, it was possible to identify the role of digital media within the organisation's activities and how these digital tools could facilitate Responsible Innovation in the agricultural sector. The findings suggest that effective innovative solutions do not just have to come from novel technologies but from the novel application of existing technologies into new contexts. Simple ICT technologies such as radio and mobile phones were found to assist the organisation in overcoming long-entrenched structural barriers such as poor infrastructure as well as lack of access to markets, capital, government support and knowledge, which currently plague the sub-Saharan African context. Radio's broad reach and accessibility was found to be an inclusive medium for sharing knowledge and allowing farmers to learn from each other. Social media was identified as an effective tool for enabling the inclusion of youths and assisting the innovation process to respond challenges and reflect on future trajectories. Finally, the ability of mobile learning apps to tailor their content to specific contexts, as well as their combination of text and internet were found to be useful for suitably replacing in-person visits from technical officers. However, for agricultural organisations to fully drive innovations that are ethical, resilient, and sustainable, this study showed that a broader conception of inclusion along gender-based terms as well as a greater emphasis on anticipating potential impact is needed. This study can therefore serve as a next step in the theoretical and practical development of responsible within the agricultural sector.

KEYWORDS: Agriculture, Digital Media, Responsible Innovation, Africa, Smallholder Farming

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1. Introduction

Smallholder farmers in Sub-Saharan Africa represent an estimated 60 percent of the population, and account for around 23 percent of the region's GDP (Goedde, Ooko-Ombaka & Pais, 2019). Yet, despite their global and regional significance as producers of horticultural products, it is concerning that a number of reports indicate that agricultural growth within this sector has stagnated in the last decade (Oya, 2012; Wiggins & Keats, 2013). This appears to be primarily due to smallholder farmers' lack of sustainable access to capital, land, markets and knowledge, all of which has been exacerbated by local government focus on other sectors within the economy (Jayne, Mather & Mghenyi, 2010). For many of these smallholder farmers, the path out of this cycle of poverty and limited growth will come from unlocking the potential of the agricultural sector (Porciello, Coggins, Otunba-Payne & Mabaya, 2020)

Motivated by this need to understand the nature and magnitude of constraints on smallholder farmers in sub-Saharan Africa and to stimulate effective solutions to the issues they face, a case study of seed developer East-West Seed was conducted. East-West Seed is a leading seed breeder with operations in Asia, Africa and Latin America. The company's central focus is the improvement of tropical vegetable seed varieties to meet the needs of smallholder farmers in array of markets and growing conditions (East-West Seed, 2021). To achieve this, East-West Seed makes use of innovative hybrid seed technology in their research and development process. In so doing, the company aims to increase both crop quality and yield to assist farmers to improve their livelihoods. Most significantly for this research, the organization has a non-profit foundation, known as the Knowledge Transfer, which aims to facilitate the development and strengthening of the vegetable crop value chain through climate smart extension services. These services have been primarily delivered through demonstration plots and in-person training. More recently though, the Knowledge Transfer has begun to explore and harness digitally enabled media to support and benefit their intended beneficiaries through the dissemination of farming knowledge to drive innovation throughout the agricultural value chain.

The introduction of digital technology to the agricultural process is not new but, within sub-Saharan Africa, East-West Seed's digital activities may represent an exciting step forward in the advancement and revitalization of the region's agricultural sector. Digital media connects stakeholders in a data sharing network that could potentially advance the goals of farming and society. Yet, before the agriculture sector runs headlong towards the possibilities and advancements these digital media could bring to the struggling sector, a critical eye should be cast over the potential socio-ethical concerns that such technology

might bring to the sector and its smallholder community. Digital technology that improves farmer's access to markets is an admirable goal but not if it comes at the expense of its end-users and community.

There is a steadily growing body of research surrounding the concept of responsible innovation and how it seeks to align technology with the values and norms of the envisioned end-users (Rose & Chilvers, 2018; Long, Blok, Dorrestijn, & Macnaghten, 2020). This approach may be particularly useful for the agricultural sector as this area is still dominated by top-down, non-inclusive approaches that rarely include stakeholders and are often unresponsive to the needs of society (Rose & Chilvers, 2018). Such an application may also be a necessity within the context of Africa, as academic research within this setting still remains scarce and much skewed towards a Western perspective (Wolfert, Ge, Verdouw, & Bogaardt, 2017). In addition, there remains a significant gap in research on the use and impact of digital media and technologies within the agriculture sector. As pointed out by Porciello et al. (2020), much of agricultural research has brushed upon but failed to provide evidence for how digital media could foster greater climate resilience, inclusivity and incentives for an enabling environment to create growth.

Therefore, this research will aim to explore the following research question: *How do agricultural organisations create responsible innovation using digital media within the farming sector in sub-Saharan Africa?* In addition, and to aid in the answer and focus of the above research question, this paper will also explore the following sub-questions: (1) *How can digital technologies be leveraged to support contemporary entrepreneurship in the agricultural sector of sub-Saharan Africa?;* (2) *What is the organization's understanding of responsible innovation in their sector and the challenges and opportunities of shifting their business to be more ethical, sustainable and resilient?*

To conduct this investigation, previous theoretical and empirical studies surrounding agriculture, innovation, stakeholders and digital technology was examined to provide a framework and background of understanding. Following this, a case study of East-WestSeed's Knowledge Transfer and its activities was undertaken using interviews, focus groups and document analysis as the primary methods of inquiry to uncover and evaluate how the organisation is utilizing digital media within the agricultural sector. Finally, the results of the analysis were examined and discussed in relation to wider trends occurring in the agricultural industry and using the theory of responsible innovation to answer the above research questions, and draw final conclusions on the study's wider implications.

2. Theoretical Framework

The agricultural sector in sub-Saharan Africa is a complex environment with a number of challenges as well as opportunities. To fully understand the ecosystem in which digital technologies are emerging and being used within the sector, this chapter will focus on reviewing previous studies to build a framework of understanding and guidance. In so doing the aim is to identify how and where responsible innovation could be applied to improve not only farmer livelihood and societal wellbeing but also sustainability within the farming sector.

2.1 Farming In sub-Saharan Africa

African agriculture is characterized by small family-run businesses where management and ownership are combined within a mature, strongly regulated market (Dias, Rodrigues & Ferreira, 2019). These farming households or smallholder farmers derive their livelihood from land ranging between two to ten hectares in size (Jayne, Mather & Mghenyi, 2010; Munyua, Adera & Jensen, 2008). The family provide the majority of the labour and the farm is typically a mix of commercial and subsistence production (Jayne, Mather & Mghenyi, 2010; Munyua, Adera & Jensen, 2008). In the majority of cases, the farm is the principal source of income for the smallholder farmer.

It is estimated that small-scale agriculture provides a livelihood for over 70 percent of the African population (Munyua, Adera & Jensen, 2008). Yet, despite the significant role of smallholder farmers within sub-Saharan African regions and economies, academic research into the sector remains somewhat scarce. Research agendas appear to be currently driven by large farming groups as well as high income countries (Huijsmans, Ambarwati, Chazali & Vijayabaskar, 2020). In addition, the general perception of smallholder farmers within the academic field shows the group to be largely underrepresented, undervalued, and mostly associated with poor or rural communities (Huijsmans, Ambarwati, Chazali & Vijayabaskar, 2020).

(1) Challenges

From the research that has been conducted examining small-scale agriculture and farmers in sub-Saharan Africa, a number of challenges for the sector have been identified. These challenges serve to trap smallholder farmers in a vicious cycle that prevents them from expanding their production and subsequently their ability to generate a suitable livelihood. As a result, this makes it difficult for smallholder farmers to access products and technology that fits their needs.

In Jayne, Mather and Mghenyi's (2010) comprehensive analysis of household survey data from five African countries, including Ethiopia, Kenya, Malawi, Mozambique and Zambia, eight principal challenges to the viability of small-scale farming were identified. These challenges include (1) disparity in land and asset holdings due to government ownership and the legacy of colonialism; (2) stagnant food crop production as a result of land pressure and infertile soil; (3) concentrated market surplus of staple grains within larger farms; (4) limited access to non-farm income driven primarily by barriers to education, capital or additional land; (5) changing urban food consumption from traditional maize to wheat and rice; (6) declining donor and state support as funding is moved to other economic sectors; (7) restrictive global agricultural trade policies that favour high income countries; (8) the impact of HIV/Aids related deaths on poor farming households. In addition, further challenges were outlined by Kidane, Maetz and Dardel (2006), including (9) weak linkages between agriculture and other sectors; (10) reduced labour due to rural-urban migration; (11) inadequate market information; (12) conflicts and disasters; (13) limited access to animal and mechanical power.

Furthermore, education has also been acknowledged in studies as an additional constraint on the sector. Education has been recognized as one of the most effective pathways out of poverty and to broaden household income, especially for smallholder farmers with limited access to land and restricted by structural barriers (Jayne, Mather & Mghenyi, 2010; Huijsmans, et al., 2020). Educated farmers have been found to be better able to incorporate new technology into their processes and articulate their interests to service providers (Guzman & Javier Santos, 2001). Moreover, a few studies indicate a link between education and digital literacy (refs). Access to education fosters greater levels of literacy, which in turn improves farmers' ability to make use of web-based tools such as mobile learning apps, the internet, and social media (Huijsmans, et al., 2020).

Yet, many smallholder farmers find themselves in a position where they are unable to pursue their education. This may be due to lack of funding or government support, access to schools due to rural locations (Jayne, Mather & Mghenyi, 2010; Barrett, Reardon & Webb, 2001) or in some instances exacerbated by family expectations to continue working on the family-owned farm (Huijsmans, et al., 2020). These farmers are then unable to expand their opportunities and sources of income outside of the farm, which Barrett, Reardon and Webb (2001) have shown to have a negative effect on overall household welfare. Contributing to the brutal cycle of limited land, stagnant food production and resultant lack of income.

Interestingly, in addition to education, age also appears to play a crucial role within the sector. Research shows that agriculture does not appeal to young people. Respondents in

Huijsmans, et al., (2020) analysis of rural farming youth in India and Indonesia indicated that farming was not considered an aspirational career. Young people from farming households would attempt to postpone their inevitable return to the farm for as long as possible. A study conducted in the United Kingdom by Hamilton, Bosworth and Ruto (2015) also showed that young people are less likely to be farmers or agricultural entrepreneurs, often choosing to move away from their farming households to start non-agricultural businesses. What is concerning is that young farmers are a huge asset to the sector as they are typically more productive and achieve higher profitability and investment (Hamilton, Bosworth and Ruto, 2015). Older farmers in comparison are more resistant to change, less likely to adopt new technology or diversify their activities (Morris, Henley & Dowell, 2017). It should be noted, though, that these studies were conducted outside of an African context, which makes their application somewhat relative.

Gender is another dimension identified within research as a limiting factor to smallholder farm viability and success. Lans, Seuneke and Klerk (2017) found in their study that women played a crucial role as initiator and developer of new farm business. Mangheni, Tufan, Nkengla, Aman & Boonabaana (2019) established that women were often the main source of labour, estimated to comprise 50% of the agricultural workforce in sub-Saharan Africa. This is primarily driven by land pressures and low productivity, which pushed male members of the household into urban areas in search of work. As result, women are frequently in charge of maintaining household food security and building up family incomes. Yet, gender inequality within the sector has systematically restricted women from access to credit and education, preventing them from contributing more meaningfully to the farming community (Dias, Rodrigues & Ferreira, 2019). These findings were also echoed in the Huijsmans, et al., (2020) study, which found that the end of education and early marriage accelerated the process of women becoming full-time farmers and closed alternative career options or sources of non-farm income.

(2) Opportunities

While the challenges facing smallholder farmers in sub-Saharan Africa are plentiful, a number of research studies have also identified opportunities in the sector as well. These prospects may hold much potential for agricultural organisations to tap into and drive improvement within the sector.

First and foremost are farmer-led innovations. In their study of farming households in Northern Ghana, Tambo and Wünscher (2017) found that farmer-led innovations, as opposed to externally produced innovations, significantly increased household income as

well as reduced household food insecurity. Although, it should be noted that the innovation was far more impactful on a household if it was a modification of an existing technology or technique rather than an entirely new innovation. In addition, diversification has also been highlighted as a promising source of opportunity for smallholder farms. Within the field of agricultural production, diversifying to new crop types for instance has been shown to limit pest damage and crop losses (Dias, Rodrigues and Ferreira, 2019).

Government policies and interventions hold great potential for providing opportunities for the sector as well. Jayne, Mather & Mghenyi (2010) have suggested that market facilitating public investments and policy choices, particularly investment in physical infrastructure can help expand the market for smallholder farmers. Improved infrastructure may boost regional trade by streamlining the link between rural farmers and urban demand centers, helping to enhance smallholder livelihood as well as economic growth in the sector (Kidane, Maetz & Dardel, 2006). Such adjustments may help to rectify the current regulatory frameworks that support import surges and limited access to developed trade markets, which has restricted smallholder farmers from expanding their production (Kidane, Maetz & Dardel, 2006).

The most encouraging opportunity for the sector appears to come from a digital technology. The digitization of farms may be a promising technological fix for wide range of societal problems including improved food production, reduced costs, diminishing environmental impact and increasing food safety (van der Burg, Bogaardy & Wolfert, 2019). The application of such technology ranges from crop science and precision agriculture to smart farming and information communication technologies. A number of researchers have also suggested that digital technology may also help entice young people back to the sector and improve opportunities for furthering farmer education (Jayne, Mather & Mghenyi, 2010; Huijsmans, et al., 2020; Dias, Rodrigues and Ferreira, 2019).

2.2 Digital Technologies & Agricultural Entrepreneurship

Much of the academic research surrounding the application of digital technologies in agriculture centres on technological advancements such as precision agriculture or smart farming (Wolfert, Ge, Verdouw, & Bogaardt, 2017). While these areas of innovation are exciting for the sector, the actual application to rural sub-Saharan Africa smallholder farmers is challenging. First, because small-scale farmers have a low uptake of new technologies (Kidane, Maetz & Dardel, 2006; Munyua, Adera & Jensen, 2008). This appears to be driven by limited knowledge, literacy, training, and lack of support for the implementation and use of the products. Second, most rural areas lack basic infrastructure such as electricity and

internet to make effective use of these new technologies (Kidane, Maetz & Dardel, 2006). The phenomenon known as smart farming, for instance, makes use of big data and technologies such as cloud computing and the Internet of Things (IoT) to enhance farm management tasks (Wolfert, Ge, Verdouw, & Bogaardt, 2017). Big data requires a set of techniques and technologies with new forms of integration to reveal insights from datasets that are diverse and of a massive scale (van der Burg, Bogaardy & Wolfert, 2019). Interpretation and analysis of the data collected and generated by these tools requires a high level of digital literacy. For rural-based farmers such as those in sub-Saharan Africa, who have only recently been exposed to smartphones, it is not yet feasible to expect them to have the skills to manage and effectively use these AI or big data driven tools (van der Burg, Bogaardy & Wolfert, 2019). Moreover, much of these smart farming technologies may not be aligned with the interests of smallholder farmers as corporations primarily focus their big data enabled technologies for use on large commercial farms for optimization (Wolfert, Ge, Verdouw, & Bogaardt, 2017).

Rather, Munyua, Adera and Jensen (2008) suggest that a lower level of digital technology in the more accessible and familiar forms of radio, television, the internet and mobile phones are better suited to the smallholder farmer context and their available resources. These Information Communication Technologies (ICT) or digital media tools have the ability to connect communities across distances, increase the extension of development services and even create a network for sharing information and learning with less reliance on costly infrastructure (Aker, 2011). In their study of emerging ICTs and their potential use within small-scale agriculture, Munyua, Adera & Jensen (2008) found that radio, mobile phones and web-based apps had the highest penetration and use within the sector. Moreover the study suggested that these ICTs eased the farmers' ability to receive information on markets, crop prices and potential produce buyers, as well as gain access to training and agricultural information. These findings have been echoed in other studies such as Morolong's (2006) examination of the mobile phone for driving development in Africa, in which he found that they effectively helped farmers to reduce transaction costs, broaden trade networks and facilitate search for employment. The ICTs capabilities, therefore, appear far more in line with farmer interests and in addressing their challenges within the sector.

Mainstream entrepreneurship research has largely overlooked the agricultural sector, in part because the industry has been long held as a fixed, traditional, and separate from other economic activity (Rose & Chilver, 2018; Dias, Rodrigues & Ferreira, 2019). However, a number of studies are showing how agricultural entrepreneurs can leverage ICTs to meet the rapid changes in supply and demand faced by small-scale farmers. In Kenya for example,

the company M-Pesa has turned mobile phones into an electronic money transfer channel using SMS. Farmers are then able to pay farm workers and make purchases of farm inputs through their mobile phone (Vodaphone, 2020). Community radio stations are also being used to share development and agriculture information for farmers (Komodromos, 2021; Silvestri, Richard, Edward, Dharmesh & Dannie, 2020). Radio Farm Forum in Zambia for example, is a government led discussion forum that aims to address common needs and problems of resource deficient farmers (Komodromos, 2021). A combination of both ICTs was demonstrated by Silvestri et al. (2020) in their Tanzania-based study to greatly improved farmer uptake of new legume-based sustainable agricultural intensification practices and technologies.

These agricultural entrepreneurs display what Rauch, Wiklund, Lumpkin and Frese (2009) term an Entrepreneurial Orientation (EO). This concept is characterised by dimensions of innovativeness, risk taking and proactiveness. The use of EO has been shown to help decision-makers develop an organisational goal, sustain their organisational vision and create competitive advantage. For agricultural organisations, both EO and the examples of how ICTs are being leveraged in the sector, hold a lot of potential for contributing positively to their organizational performance and entrepreneurial strategy process as they strive to improve smallholder farmer livelihood.

Agricultural entrepreneurship is still a growing research area and academic studies have paid relatively little attention to the benefits and use of ICTs within small-scale agriculture. In addition, most ICT initiatives are project-based and driven by government or non-profit organisations making the findings disjointed and uncoordinated (Munyua, Adera & Jensen, 2008). However, as can be seen from the research, both ICTs and EO may be essential to support farmers as they face a complex environment and develop new strategies and responses to improve their agricultural livelihood.

2.3 Responsible Innovation in Agriculture

The uptake of ICTs in African agriculture is still somewhat slow, which is holding the sector back from realising its technological potential. However, this may be a welcome window to explore the ethical concerns that come with innovation in agriculture. Innovation has long held a desirable status amongst entrepreneurs and businesses as a driver of change and financial success. Yet it is not typically a concept applied to agriculture, specifically African agriculture, which has long been viewed as technologically backwards (Poulton & Kanyinga, 2014). Yet, despite this perception, the rise of ICTs and other technological

innovations certainly indicates that there is a real-world need to examine the sector through an innovative lens.

The concept of responsible innovation may be the best suited for the exploration of digital technologies in agriculture. It has been shown to play a key role in overcoming sustainability issues and helping business models impact socio-economic systems through the integration and management of socio-ethical issues into the innovations themselves (Rose & Chilvers, 2018; Long, Blok, Dorrestijn and Macnaghten, 2020). Responsible innovation can, therefore, be understood then as an open and interactive process, in which both the needs of societal actors and innovators are taken into account in the innovation process (Von Schomberg 2013). Rose and Chilvers (2018) advocate that responsible innovation should encourage the creators of the innovation to think about what the technology is for, who it serves and who is driving the process. This, they argue, is achievable if the responsible innovation is anticipatory, inclusive, as well as responsive and reflexive to problems, people and technology. Nordmann (2014) further clarifies that responsible innovation is an ethical approach when it promotes vigilance and is informed by historical experience and consideration of future consequence.

Although, the application of responsible innovation to the sector does come with several challenges, Gremmen, Blok and Bovenkerk (2019) note that society's reliance on agriculture for food means that irresponsible agricultural processes cannot be immediately abandoned. Due to the interrelation of species, any innovation within agriculture carries multi-dimensional risks as a number of ecosystems will be affected. Most crucially, the ethical status of farming, whereby organisms and ecosystems are both the subject and object of the innovation process, means that responsible innovation frameworks developed outside of agriculture cannot be easily applied to the sector. Most innovations occur within a commercial setting (da Silva, Bitencourt, Faccin & Iakovleva, 2019), yet the inclusion of responsible innovation within the competitive contexts of commercial industry creates tension between business objectives and ethical responsibilities (Long, et al., 2020). This is further exacerbated when the responsible innovation framework is executed from a policy or socio-ethical perspective with a focus on academic research and development rather than a commercial setting (da Silva, et al., 2019). As a result, much of the academic research on responsible innovation calls for the development of a framework that is suited to the specific context of investigation, in this case agriculture in Africa.

The risk of not developing such a framework to guide the innovation process to meet the needs of the sector is unchecked ethical issues. With the integration of digital technologies into agriculture has come novel concerns such as privacy and ownership of data as well as

new power imbalances. For example, in the development of a new ICT platform, decision-making power may move out of the hands of the farmers and into those of private companies or technology providers who are creating and providing the innovation. This process known as platform capitalism turns the platform and the data it gathers into a lucrative resource as well as a source of competitive advantage and economic power for the companies controlling the platform (Srnicsek, 2017). As a result, a high premium is placed by these platforms on getting data, often at the expense of individual's privacy and other ethical considerations. Technology within this context becomes a double-edged sword that holds the potential to bring both harm and benefit from its use.

Although, it should be noted that the formulation and application of responsible innovation is not without its criticisms. Genus and Iskandarova (2018) for instance argue that the conceptualisation and definition of responsible innovation as well as its institutionalisation is being driven by the global north, in particular the US and EU. This potentially results in a conception that does not fully question the actual need or usefulness of responsible innovation in the contexts it is being applied. In addition, there is the risk of marginalising certain stakeholders from inclusion in the innovation process simply because they are not present in the US or EU contexts. Delvenne (2017) also argues that responsible innovation diverts attention away from the problems created by innovation and encourages a viewpoint that only sees the 'social good' it creates. With these critiques in mind, particular attention will therefore be paid to whose interests are being served by the innovation and towards what goals it is working. Therefore, drawing out the socially desirable and sustainably minded aspects of responsible innovation that make it a powerful driver of ethical innovations.

2.4 Stakeholder Analysis

Stakeholders are any group or individual that can affect or be affected by the organization fulfilling its goals (Da Silva, et al., 2019). As has been shown in the above sections, agricultural organisations, governments, traders, agricultural-input dealers, farmers, and the surrounding communities are significant stakeholders within the agricultural and innovation process.

Within responsible innovation literature stakeholder management is a key task due to its consideration and inclusion of socio-ethical issues into the innovation process (Long, et al., 2020). However, despite the well-recognized need for stakeholder inclusion, the majority of literature is unclear about which stakeholders to involve, at what stage of the process or how to ensure the stakeholders are representative of the affected groups (Da Silva, et al.,

2019). To help guide the inclusion dimension of responsible innovation and overcome some of the vagaries identified above, stakeholder analysis may serve as a useful theoretical tool.

According to Varvasovszky and Brugha (2000) stakeholder analysis can be used to gain an understanding of and identify decisions within a context, particularly for the development and management of policies (Varvasovszky & Brugha, 2000). The aim of the analysis is to generate knowledge, to understand the various actors' behaviour, interest, intentions and relationships and how these might influence the decision-making and implementation of a process (Varvasovszky & Brugha, 2000). Context and culture are essential here to assist in managing stakeholders with potentially divergent demands and perspectives (Long, et al., 2020)

As Frost (1995) argues stakeholder analysis provides opportunities to develop a formal mechanism to review ethical concerns. He suggests that for each issue under consideration, evaluate the effect on the organisation as well as the actors involved or impacted. The intention of stakeholder inclusion is to broaden the vision and process of the innovation through collective deliberation and dialogue. With this focus, responsible innovation may offer a way of underpinning innovation processes in such a way as to build trust and confidence of stakeholders. In so doing, improve the connections between them to enrich the innovation process as well as meet their practical and ethical needs (Long, et al., 2020).

Da Silva, et al. (2019) advocate the early involvement of stakeholders in the innovation process. The authors found that the late inclusion of stakeholders limits the anticipation of risk and reflection within the innovation process. This is due to a dominant design being locked in too early, making it harder for the organization to be flexible and adjust the design once stakeholder feedback is sought. Moreover, late inclusion increases the risk of the innovation being rejected at market launch as well as its cost of adoption. Thus, the early inclusion of multiple stakeholders may help the innovation process overcome challenges such as power imbalances, conflict of interest and difficulty orchestrating responsible outcomes.

Thus, from the evaluation of previous empirical and theoretical research it can be seen that smallholder agriculture faces significant structural and environmental challenges including climate change, declining state support as well as unequal access to education, land and farming knowledge amongst others. Yet, digital technologies, more specifically ICTs have been identified as a potential driver of opportunities within the sector. These digital media hold the promise of bridging farmer's gap in information as well as encouraging the development of entrepreneurial activities that will aid in improving the farmers' livelihoods. In order to harness the full potential of these technologies, responsible

innovation is advanced as the most suitable conceptual framework to guide the processes and ensure that these remain ethical, sustainable and encourage an upstream approach to innovation, which is sorely missing from much agricultural research and development. In addition, to help aid the critical inclusion dimension of responsible innovation process, stakeholder analysis has been identified as a useful approach for this study. Following the development of this study's theoretical framework, the next chapter will outline this study's method of investigation, data collection as well as analysis to answer the identified research questions.

3. Method

Responsible innovation is still a relatively new concept within academia and even more so within the agricultural sector. As a result, the processes and behaviours that drive this contemporary phenomenon are still little understood. Therefore, this chapter outlines the methodological choices and decision making undertaken to provide a detailed roadmap of data collection and analysis. In doing so, the intention is to help clarify and gain a deeper understanding of responsible innovation and its creation through digital technology by agricultural organisations.

Qualitative research is centred around the notion of studying a phenomenon in its natural setting. This interpretive approach allows for the researcher to make sense of an event through the meaning people bring to it. In so doing, the approach is able to uncover nuances in perspectives and interpret everyday practices at a deeper level of insight (Flick, 2007), which makes it ideal for exploring the still novel application of responsible innovation within the agricultural context. Within qualitative research design there are a number of approaches or traditions available to the researcher to guide the focus of the study. As the aim of this study was to: (1) identify the contextual factors and features of digital technologies that facilitated support of entrepreneurial activities in the agricultural sector, and (2) study agricultural organisation's understanding of the opportunities and challenges of responsible innovation within the sector and their business, a case study was deemed the most suitable approach. The case study approach is useful in this context as it involves and is accessible to multiple audiences. Using qualitative methods, it can document participant and stakeholder perspectives, engage them in the process, and represent different interests and values in the programme. Case study reports that are issue-focused, comprised of naturalistic interview data and written in the language of participants, allow access to findings that others can recognize and use as a basis for informed action (Simons, 2009). According to Yin (1989) when implemented as a research strategy, the case study can be successfully used to explore concepts that are sensitive or ill-defined, while also taking into account the context, history and existing knowledge about the phenomenon. Through the detailed observations of different aspects and comparison of perspectives entailed in the method, the case study also has the advantage of creating a holistic view of the process.

However, as Gerring (2004) cautions, case studies represent both a useful and contentious method of research due to their open design and data collection procedures. To mitigate some of these difficulties, a number of design decisions were made to ensure the case was tailored to addressing the research question, as well as to determine whether the

findings were transferable to other instances or contexts (Schreier, 2018). These design decisions included: (1) *selection of cases*; (2) *unit of analysis*; (3) *sampling time*; (4) *boundaries for study*.

(1) *Selection of Case*

Following Meyer's (2001) recommendations for case selection, the decision was taken to select hybrid seed developer East-West Seed as the sample case for this study. The choice of organisation was guided by two factors. The first is East-West Seed's similar organizational activities in Uganda, Nigeria and Tanzania, which makes it suitable for comparative purposes across the three countries. This allows for a somewhat representative view of the application, reception and adoption of ICTs within the African continent.

In doing so, the aim is to reduce some of the concerns of generalizability and inherent bias that can arise from a single case study while also providing depth within the investigation (Meyer, 2001). The second factor is the organisation's NGO-orientated division called the Knowledge Transfer. The Knowledge Transfer focuses on the upskilling and development of African smallholder farmers in each of the respective countries. Within this process the Knowledge Transfer employs a variety of media technologies to disseminate knowledge and communicate with smallholder farmers. Making the division ideally suited to explore and extend the emergent theory of responsible innovation within the agricultural sector.

(2) *Unit of Analysis*

According to Yin (1989) within case studies there is the choice to follow either a holistic or embedded design. As this is a single case study, the decision was taken to follow an embedded design, which entails focusing on sub-units for comparison. As the aim of this study is to understand the creation of responsible innovation and the role of media technologies within that creation, the most important units of analysis were the innovation process, as well as the choice and application of the media technologies. In addition, the comparison of subunits has also been noted to help minimise researcher and respondent bias present within a case study (Meyer, 2001).

(3) *Sampling Time*

When conducting a case study there are a number of decisions to make around sampling time, as setting a time reference can help in establishing and explaining the changes that can be seen within a case (Meyer, 2001). The decisions here include the number of data collections and when to enter the organisation. As the emphasis in this study is the innovation process taking place within East-West Seed or more specifically the Knowledge Transfer division, the first decision was to collect retrospective and real-time data at two

distinct periods. The first period is the initial application of a media technology in the agricultural sector by the Knowledge Transfer team. This was collected retrospectively. The second period is the current application of the media technology, collected in real-time, for comparison and evaluation of the process over time. Collecting data on a continuous basis would have likely provided greater detail and mapping of the innovation process, however due to access and feasibility constraints this was not a possibility. However, the comparison of the two distinct periods did allow for a greater contrast of the findings.

(4) Boundaries of Study

The final design choice is the boundary of the study, which is set through the criteria of importance, relevance, and representativeness (Meyer, 2001). Following this criterion, the decision was taken to concentrate on the Knowledge Transfer division of East-West Seed. The department was directly responsible for the application of media technologies within the agricultural sector and the resultant process of innovation. The application of a digital technology to share knowledge and connect with smallholder farmers was viewed as the most important, relevant, and representative focus for the responsible innovation process.

3.1 Sample

Following a desire for detailed knowledge of the case and for grasping a variety of perspectives, this study drew its sample from two sources: informants and documents.

For the informants, a strategy of maximum variation sampling was applied with key informants selected purposively from the employees of the Knowledge Transfer division in Uganda, Tanzania and Nigeria. The central idea underlying purposive sampling is to select instances that are information rich with a view to answering the research question (Schreier, 2018). Here, the researcher started out by identifying factors that lead to variation in the phenomenon under study, these included principally the role within the organisation. These then served as a broad framework orienting the sampling process, with a view to including as much variation in the sample as possible (Schreier, 2018). Maximum variation sampling is especially useful for representing different aspects of a case, such as persons, points in time, or contexts (Schreier, 2018).

The criteria for selection included that the participants must be from populations representing multiple perspectives and they must be knowledgeable about the Knowledge Transfer's innovation process. A total of sixteen informants were sampled from the Knowledge Transfer population with eleven men and five women. Their roles included management, coordinator and technical field officer. According to Glick et al., (1990) an advantage of using multiple informants is that the information provided by one informant

can be checked against the information provided by other informants. In so doing help to resolve any discrepancies and ensure greater validity of the findings. This is especially crucial here as this study draws on a single case for analysis.

In addition, two informants, both male, were drawn using convenience sampling from the farming community in Tanzania that had interacted with the Knowledge Transfer team. Due to a lack of English understanding, and the resultant need for a translator, as well as poor internet connection in the rural areas, no additional informants were sampled from this population. Access to all the informants was facilitated by the upper management of East-West Seed.

For the documents, sampling was driven by practical and conceptual issues in an iterative process. Relevance for document choice was tied to the fieldwork being focused on and exploring the key aspects of the phenomena (Simons, 2009). The external-facing documents were publicly available with free access to anyone, and so specific permissions was not needed to collect them. The final archive of the external documents included policy research working papers, systematic scoping reviews and reports from think tanks, NGOs and conferences focused on the use of digital media in the agricultural sector. For the internal documents, explicit permission was required for their access and collection from key senior gatekeepers within East-West Seed and the Knowledge Transfer. The final archive of the internal documents included project key performance indicators, project proposals, end of season reflection reports, implementation reports, project baseline reports, training materials, crop and technical guides, annual and quarterly social media reports. Analytically, these documentary resources were not central, but helped in the understanding of the interviews and focus groups. They also enabled the researcher to map the ideals around innovation and media technologies embedded within the documents and the organisation's policies (Simons, 2009).

3.2 Data Collection

For this study, the process of data collection was driven principally by its research aim as well as its case study approach. It is typical for case studies to combine multiple methods and data sources to enhance the validity of research findings (Gerring, 2004). This process known as triangulation, ensures that the phenomena is considered from at least two perspectives to provide a comprehensive understanding of the complex social situation (Flick, 2018). Thereby, this provides a stronger substantiation of concepts and hypotheses (Meyer, 2001). For this study, the primary data collection methods included interviews, focus groups, and documents from both internal and external sources. Due to time, resource

and access constraints, alternative data collections including surveys and observations were not feasible for this study.

(1) Interviews

Interviews are a useful data collection tool as it allows for the gathering of information that may not be readily articulated in the texts or documentation sourced from East-West Seed and outside sources. For this study, semi-structured interviews were conducted to allow the researcher to collect explorative data on the lived experiences of the participants and the meaning they brought to responsible innovation within agriculture and media technologies. Semi-structured interviews are characterised by interview guides which contain general topics that serve as the basis for questioning (Roulston & Choi, 2018). This allows for the researcher to sequence questions to generate free-ranging conversations about research topics with participants leading the interaction. The interview guide was formulated using previous research into sub-Saharan African agriculture as well as responsible innovation to generate questions that elicited descriptions that spoke to the research question. The sequence of questions began with broader questions before moving to more specific questions and included potential follow-up topics (Roulston & Choi, 2018).

A total of five interviews of an average of 50 minutes were conducted by the researcher. As the informants were located in either Uganda, Tanzania or Nigeria, the interviews were internet-mediated using voice over Internet protocol platforms. With the informants' permission, the interviews were recorded and then transcribed verbatim for further analysis to ensure accuracy as well as closeness and richness of data. The interviews helped generate detailed descriptions of participants' experiences of media technologies and agriculture in Africa through asking open questions concerning the participants' feelings, perceptions, and understandings. These descriptions then formed the basis of the reconstructed interpretations or 'manifestations' of responsible innovation that is the focus of this inquiry (Roulston & Choi, 2018).

(2) Focus Groups

The defining feature of focus groups is the use of group interaction to produce qualitative data through the process of sharing and comparing (Morgan & Hoffman, 2018). For the researcher, this form of exchange was particularly useful as it allowed for an interactive discussion that produced a variety of perspectives and experiences as participants shared not only what they thought but why they thought that way. Such a dynamic was not available within the interviews and so added a layer of nuance to the collection of data for this study.

Group composition is an essential consideration within focus groups as a well-chosen group has the potential to produce rich interactions through the sharing and comparing. Unfortunately, the groups within this study were chosen not by the researcher but the respective managers of Uganda, Tanzania and Nigeria teams. These chosen groups consisted of the various Knowledge Transfer employees and ranged in size from seven to nine people. The team's familiarity with one another allowed for the maximizing of common ground and ensured the groups felt comfortable sharing with one another. On the other hand, the presence of the managers within the groups may have contributed to an asymmetry and affected power dynamics (Morgan & Hoffman, 2018). As a result, the participants might have experienced some discomfort in discussing certain topics.

For the Ugandan focus group, a dyadic interview was undertaken with only two informants participating. Dyadic interviews are similar to focus groups in that they seek to accomplish the 'sharing and comparing' dimension in interaction, but they limit the dynamic of a conversation between two people, rather than the complexity of multiple participants engaging in a lively discussion (Morgan & Hoffman, 2018). Smaller sizes are particularly appropriate for situations where the participants have a high level of engagement with the topic as was the case in this instance.

As the aim of the focus groups was to hear the participants' wide-ranging thoughts about the topic, with less emphasis on the specific types of questions, a less-structured interview format was used. This entailed reducing the original interview guide to a few key questions to encourage a dynamic discussion with a wide range of unanticipated responses (Morgan & Hoffman, 2018). However, this did sometimes allow for the interview to take a direction that was not necessarily productive for the overall study.

(3) Documents

Documents shape, and are reflexively shaped by, our perceptions, interactions, institutions, policies, and society. They are central in the production, reproduction and transformation of our contemporary landscapes. Yet, formal document analysis tends to be less used than interviews in case study research (Simons, 2009). However, they have been found useful to enrich and portray the context of the phenomenon under study. Written documents may be searched for clues to understanding the culture of organizations, the values underlying policies, and the beliefs and attitudes of the writer (Simons, 2009). As stated by Meyer (2001), such documentation was also useful as input guides for interviews as well as for counteracting any biases within the interviews. The documentation also assisted in tracing the history of digital media use and development in agriculture for better context.

Access to the internal documents was facilitated by gatekeepers within the Knowledge Transfer division. Following a discussion with the gatekeepers, an initial collection of documents was sampled. These documents were then appraised for their relevance, credibility and authenticity to assess their fit with the research question and the other external documents in the data set. This iterative process of searching, pre-coding, and analysis was then repeated in a second round of data collection, following the first sets of interviews and focus groups. In this way refining the material to produce something that is both practically manageable as well as analytically rich (Rapley & Rees, 2018). For the external or publicly available documents, the above steps were also undertaken. Although, here, the data collection took place in a single round.

3.3 Data Analysis

Qualitative case study tends to depend heavily on the interpretative skills of the researcher (Simons, 2009). These interpretations are often personal and intuitive, reflect different experiences and differ widely from one researcher to another. According to Simons (2009), interpretation requires total immersion within the data, re-reading interview transcripts, documents and field notes as part of the process. As a result, it is not always easy to establish guidelines for analysis that are replicable or appropriate in all situations. Therefore, a formal inductive process of breaking down data into segments or data sets which can then be categorized, ordered and examined for connections, patterns and propositions that seek to explain the data is needed.

For this study, data reduction and analysis were conducted following a 5-stage procedure adapted from Meyer (2001), which includes (1) establishing chronology, (2) reducing the data to issues and themes, (3) organizing and revising of the data, (4) drawing data conclusions, and (5) analytic generalization. The first step was to outline the chronology of the case using internal and external documentation. This helped to make sense of the data and begin the immersion process. The second step of data reduction entailed selecting, focusing and abstracting key data from interviews, observations and field notes. Here, the researcher was guided by choice of questions, methods and conceptual frameworks. The third step aimed at building up facts using the documentation and filling in perceptions using illustrative examples from the interviews. Data conclusion and verification is the process through which emerging patterns, propositions and explanations are gradually confirmed and verified. This step involved the application of the four dimensions of responsible innovation to the analysis. According to Rose and Chilvers (2018), these dimensions include anticipation, inclusivity, responsiveness and reflexivity. By applying these dimensions, the

aim was to allow the unique patterns of the case to emerge and to gain a rich familiarity before expanding out to a comparison with wider theory (Meyer, 2001). The final stage, therefore, was analytical generalization. Within this stage, the emergent findings were compared with previously generated theories from the responsible innovation field. This comparison involved examining what is similar, what is different and possible reasons why. According to Meyer (2001), this stage enhances the generalizability, validity and theory-building of the case study. A further examination of literature that both supports and conflicts with the findings also helped to strengthen the accuracy of the findings as well as force the researcher to go beyond initial impressions (Meyer, 2001). While more loose than formal methods of analysis, these processes were important as they helped to retain the holistic nature of the data, ensuring that it was not detached from the context in which it arose nor the researcher who collected it and was now ‘making sense’ of it.

To conclude, this chapter has discussed the sampling, data collection procedures and data analysis approach chosen to conduct this study. Following the desire to explore the somewhat novel emergence and application of responsible innovation through digital media, a qualitative case-based method was deemed to most suitable approach. Respondents were purposely sampled from the Knowledge Transfer employees using a maximum variation strategy in order to gain a wide as possible perspective on the innovations taking place within the organization's digital activities. The addition of both internal and external documentation within the data sample informed these findings and provided context for the interviews and focus groups. The development of a framework prior to data collection was also shown to be useful in guiding the final collection of data and later analysis. Finally, as was shown in the analysis section, the decision to follow the established procedures of Meyer (2001) ensured that some rigour was established within the interpretative nature of the study's qualitative approach.

4. Results

Following the analysis, this chapter presents the main findings drawn from the data collected through interviews, focus groups and documents. Using the dimensions of responsible innovation outlined by Rose & Chilvers (2018), this section will explore the role of the Knowledge Transfer's radio, social media, and mobile learning activities in facilitating the innovation process. In addition, this chapter also critically discusses the wider implications of the findings for the agricultural sector and the theory of responsible innovation.

4.1 Innovation is Good Agronomic Practices & Digital Technologies

From the analysis of the data, it became clear that two processes of innovation were occurring within the Knowledge Transfer's activities. The first was the Good Agronomic Practices (GAP) that the Knowledge Transfer had developed and were sharing through training programmes. These practices entailed providing farmers and other stakeholders in the value chain with access to knowledge and information about farm management, weather forecasting, business practices, and market prices and information. For many farmers across the globe, the practices were not new, but for smallholder farmers in the context of Africa, these practices were novel and radically transformative for their farm and production. As explained by the Head of Knowledge Transfer Africa,

When I went to Tanzania in 2014, 60% of farmers were not trellising tomatoes... they will just leave them on the ground. Lots of diseases... We came in with trellising, so staking off tomatoes. For the farmers of Tanzania that was innovation.

Other GAP innovations included the use of seedling trays, drip irrigation, climate resilient practices like planting trees in their fields and even the proper spacing of plants in the field. By undertaking these small changes, even on limited land space, the farmers were able to produce a better yield and improve their income as a result. The training programs have traditionally been delivered by the Knowledge Transfer in face-to-face interactions. This has been guided by the principle of seeing is believing,

When the farmer sees the variety or the technology or the technique or the practice in a demonstration, and then copy that and implement in their own field, they are able to really do things in a better way (Head of Knowledge Transfer Africa).

The second process of innovation occurring within the Knowledge Transfer's activities is use of ICTs, specifically mobile phones, radio and the internet as tools within the agricultural process. These digital technologies are being utilised as complementary modalities to the in-person training. This entails the use of social media to provide back-up messages in text and image to the verbal learnings from the field trainings, allowing the farmers to refer back to and share the information for greater adoption. On these various platforms the Knowledge Transfer is offering the same training, packaged in the form of social media content, mobile learning apps and radio programmes with some additions of SMS. In so doing, the Knowledge Transfer is innovating how farmers learn and engage with the new agricultural techniques and practices.

For the Knowledge Transfer team, innovation can be summarised as techniques that are new (for the beneficiary), create improvement and solve problems. This transformation does not need to be radical, in fact it is the 'lower' innovations that appear to have the greatest impact. From the discussions with the Tanzanian farmers, the incorporation of simple trellising into their farming of tomatoes has reduced funguses, diseases and most importantly loss of produce, which has a reverberating effect on their overall livelihood. Even just the reduction of land size has had a positive effect on their farming, "now [I] use a small area with the Good Agronomic Practices and [I'm] getting high yield compared to when he was producing in a large area without following GAP" (Tanzanian Farmer). In terms of the digital innovations, the techniques were not hugely advanced either. Radio, for example, a technology that has existed since the 19th century, was one of the Knowledge Transfer's most utilized and effective forms of digital media. This has interesting implications for the conception of innovation and the sector's preoccupation with advanced technologies as the most promising sites of innovation for agriculture (Wolfert, Ge, Verdouw, & Bogaardt, 2017). For the agriculture sector, it seems effective innovative solutions do not just have to come from novel technologies but from the novel application of existing technologies into new contexts. This reflects the findings of the Tambo and Wünscher (2017) study, which showed that the most impactful innovations for farming households were those that modified an existing technology or technique. These results, therefore, hold great potential for a resource-constrained environment such as sub-Saharan Africa's agricultural sector.

Linked to this, and of particular interest, was the findings on the measurement of an innovation's success by the Knowledge Transfer team. An innovation was considered successful if it was accepted and adopted by the intended beneficiaries. This understanding was echoed across the Knowledge Transfer employees' discussions and reflected in their

formulations of the projects. For instance, as explained by the Knowledge Transfer Manager Tanzania, “Knowledge Transfer activities is solely based on the beneficiaries. It's a two-way kind of project or innovation that we usually do, even the approach we get the farmers to work with”. As Responsible Innovation requires that the needs of the end-user be considered within the innovation process, the Knowledge Transfer’s measurement of innovation success indicates that their activities are initiated from a space that has the intention to be responsibly innovative.

4.2 Digital Media as a Facilitator of Inclusion

Within the concept of Responsible Innovation, the first and perhaps most crucial dimension is inclusion. Here the idea is that all stakeholders affected by the innovation must be considered within the process (Rose & Chilvers, 2018). The result of this inclusion is active participation and contribution of stakeholders towards the innovation, helping to make it more ethical and suited to stakeholder needs. The principal stakeholders within the Knowledge Transfers process include farmers, farming groups, agricultural input-dealers, Non-Government Organisation (NGOs), government extension officers and donors. Although, each groups inclusion within the innovation process was shown to vary considerably.

The demonstrations, field days and trainings were noted to include a broader range of stakeholders from the entire agricultural value chain, including like-minded NGOs, local government extension workers, agro-input dealers, universities, and donors. Here the actors took the form of either an advisory role or were involved in a specific stage of the innovation process resulting in variety of influences and impact. However, for a number of these stakeholders, their inclusion did not appear to extend to the innovation process of the digital technologies.

Donors had the least inclusion and influence on the innovation process. They set the objectives for project and in some cases the choice of approach utilised within the project but remained largely in an advisory capacity.

The local universities participation and involvement centered around as sites for the Knowledge Transfer to demonstrate their GAP innovation process. It appears from the findings that universities such as Ahmadu Bello University in Nigeria have identified the importance for their students to learn about these agricultural processes and to work with organizations like the Knowledge Transfer. As explained by the Business Development Manager in Nigeria, "we bring the demonstrations as close as possible by establishing a demonstration site in that school and then students participate". The universities therefore

are somewhat actively involved and participate in the innovation process but their influence, like that of the donors, appears to be quite minimal.

The inclusion of NGOs into the innovation process is somewhat more influential as they serve as strategic partners. These strategic collaborations with NGOs ensured the provision of expertise, knowledge or funding that allowed the Knowledge Transfer to advance their agenda in a more inclusive way. For example, the Knowledge Transfer recently partnered with Solidaridad, who are experts in community mobilization and gender issues. This partnership helped the Knowledge Transfer team when entering communities to not only look at the dimension of agriculture but also the social issues within that community. However, these NGOs participation, involvement and influence of the innovation process is largely limited to the initiation stage.

The inclusion of government extension officers, the local agricultural-input dealers and farmer groups into the innovation process took on a slightly different form. Farmer groups serve as associations or social networks for farmers to share knowledge, trainings and mobilise lobbies to the government. Agricultural-input dealers, often referred to as agro-input dealers, own stores within the communities where farmers can purchase necessary agricultural inputs such as fertilizers and pesticides. These dealers are often the first point of call when farmers need advice on pests and diseases in their fields. Finally, agriculture government extension offices are employees of the local government authority. Their role is also to help guide and support farmers in the production process. All three groups were identified by the Knowledge Transfer as key to their innovation activities. They served as gatekeepers to the community and advocates of the Knowledge Transfers practices and innovations, helping to build trust for the Knowledge Transfer's activities within the communities. All three stakeholders often served as the first point of call when farmers encountered challenges in the field, and in turn fed this information back to the Knowledge Transfer team. The team would then incorporate this information into their trainings. As a result, these stakeholders were also often recipients of specialised training from the Knowledge Transfer to ensure "there will be more reach and sustainability" (Head Knowledge Transfer Africa) in the organisation's innovation process. This is crucial as improved linkages between farmers and intermediaries has been shown to streamline formal and informal business practices across the value chain. This is a necessity for farmers to gain better access to markets and practices.

From the findings it was clear that Knowledge Transfer prioritised the smallholder farmer as the central stakeholder. The farmers' involvement and participation were actively sought throughout the process and their influence on both the GAP and digital innovations

was impactful. Before any project was initiated, whether it was a training program or mobile learning app, the Knowledge Transfer team conducted a baseline survey and interviews with the farmers to determine their current practices, their needs, and the gaps in knowledge. This information would then form the basis of the organisation's approach and choice of training as explained by the Knowledge Transfer Manager Tanzania,

So, we say okay, even if EWS KT was not there, which crops would you do this season?... So, we are asking how have you been doing this? Do you have experience in tomato production? When the farmer explains the need, it's easier for staff to understand there is a gap somewhere.

If any farmers encountered issues during the process, their case would be analysed, and advice sought to help the Knowledge Transfer team adjust the approach to meet the farmer's challenges. Following the completion of projects, farmers were given the opportunities to give their testimonies and ask questions, which again informed the Knowledge Transfer's next iteration of the project. All of which appeared to help inform an inclusive innovation process, certainly in the context of the farmers. Although, instances have been identified from the results that indicate specific groups within the farmers face challenges to inclusion for the in-person training, most especially women and youths. This appeared to be primarily driven by cultural constraints that inhibited the active participation of these key actors. Yet, the evidence from the data shows that radio, social media and to a degree mobile learning apps were effective in overcoming these barriers as well as those created by other social disparities such as education, wealth, and income.

(1) Radio

Radio programmes were central in the Knowledge Transfer's activities in Uganda, Tanzania and Nigeria. Although, the frequency of the programmes in each country varied considerably largely due to budget constraints. In Nigeria, where the radio slots were affordable, the programme was aired twice a week. In Uganda that frequency dropped to a bi-monthly programme and in Tanzania to once a month. Regardless of the programme's frequency, radio was the most accessible of the platforms as explained by the Head of Knowledge Transfer Africa, "we normally say for the smallholder farmer, the most effective way is using the radio because everybody listens to the radio". Its accessibility is largely due to its cheap cost, its requirement of batteries as opposed to electricity and its circumnavigating the issue of (digital) illiteracy amongst the farming population. In addition, the radio can be listened to in the home. All of which makes it an effective tool for the

Knowledge Transfer to disseminate its innovative techniques to rural farmers, even in areas outside of their operations. From the interviews with the Tanzanian farmers, the radio was shown to be a key learning platform for their use of pesticides and the handling of disease outbreaks in the field amongst other challenges.

In addition, farmer involvement within the radio programmes was actively encouraged and their influence was seen in the planning of the programme's topics and content to participation on the programme itself in the Q&A segments in the second half of the shows. In fact, the Q&A segment appears to be integral to the farmer's feeling of inclusion with one of the Tanzania farmers explaining, "through the radio [I have] reduced some challenges that got in the farm. Because [I] had the from the radio station, [I] had the opinion from other farmers who share their challenge". This perhaps shows that a bottom-up approach to inclusivity where farmers are learning from each other is far more effective than a top-down application of an innovation.

Crucially, the accessibility of the radio technology also ensured the inclusion and engagement of women into the training programmes. This was particularly important in Northern Nigeria, where cultural and religious constraints keep women in the home and in some cases unable to access mobile phones. All of which, restricts them from accessing and benefiting from the face-to-face training. The presence of a radio in their homes facilitated "women to participate fully in listening to [Knowledge Transfer] programmes" (Social Media Manager Nigeria), even if they did not have the opportunity to call in. As a result, while the men work in the field, the women became the primary disseminators of the programme's innovation, sharing it with the men of the household and directing the questions the men might call into the radio programme.

Social exclusion is largely under reported in studies, with few researchers investigating its downstream effects on participation (Porciello, et al., 2020). The fact that women, disadvantaged by cultural constraints, were able to use radio to overcome these obstacles, pushes a need to rethink the criteria and measurement of access. A broader conception based on a collective access rather than individualistic could create a more effective basis to improve participation, especially the inclusion of those disadvantage by their gender or other social aspects. In so doing, this will help to improve the inclusion of stakeholders within the innovation process.

A further finding of interest was older farmers indicated their discomfort with digital media and technologies, often finding the services less attractive and therefore less willing to use (Porciello, et al., 2020). Radio responds to this barrier by being not too dissimilar to face-to-face interactions as it is verbally based. Moreover, the content and trainings are

offered in approachable step-by-step segments, refined to the season and period of production currently being undertaken by the farmer. The nature of radio allows the Knowledge Transfer to reach farmers outside their areas of operation and in rural spaces that were difficult to access due to poor infrastructure, further overcoming obstacles to participation such as social factors that exclude downstream stakeholders.

(2) Social Media

The Knowledge Transfer teams in Uganda, Nigeria and Tanzania were found to utilise social media platforms within their activities to communicate their techniques, conduct their training or assist farmers in formulating virtual social networks for support and learning. WhatsApp and Facebook were the two platforms utilised across all three countries, as they were the most widely accessible platforms within the countries. Nigeria had the addition of messaging platform Telegram to facilitate larger groups of farmers and Tanzania the addition of video-based platform YouTube to provide online learning. The key stakeholders within this medium were identified as smallholder farmers.

From the analysis, social media was identified by the organisation as an inclusive medium. First and foremost because age, education, gender and locality were not barriers to participation. The wide reach of the platforms increased the Knowledge Transfer's capacity to engage and interact with farmers. The social media platforms were also free to access and in the case of Facebook Lite, available on feature phones. This was crucial as a high proportion of farmers do not have access to smartphones. The range of platforms offered by the Knowledge Transfer also allowed the farmers more choice. This has been found to increase digital technology adoption by several studies due the farmers' ability to make the technology more localized, more sensitive to constraints and culture, and interactive (Porciello, et al., 2020). This was seen particularly in the WhatsApp groups, and in the case of Nigeria Telegram groups, set up by the organisation. Each group was differentiated by language, income level and in some case crop production, to ensure that the farmers could engage in the training most suited to their needs. In so doing the farmers had a direct influence on the content through commentary and interest levels.

From the external document analysis, a recurring theme was the high cost of providing relevant advice and service to smallholder farmers. This was largely driven by the poor public infrastructure of the rural areas and the farmer's insufficient access to capital (Deichmann, Goyal & Mishra, 2016). Communication and information are crucial to farming production, especially because of its ability to facilitate access and resulting inclusion. From the results, social media is certainly shown to overcome some these barriers of cost and allow the Knowledge Transfer to disseminate their GAP techniques to the

farmers. But in order to ensure that the farmers gain the most out of these digital media options, it is essential that they are made aware that this technology option exists, how to make use of it and that is beneficial to their circumstances. There was some indication that the Knowledge Transfer was communicating the above elements through their radio programme, but perhaps greater emphasis should be placed on it to ensure a wider inclusion of the stakeholders.

An exciting potential for inclusion was identified with social media for a younger farming audience as it appeared to facilitate their engagement in the learning process. "These young farmers who are on social media also want to learn about vegetable production. We cater to them by having a social media page and WhatsApp group" (Project Coordinator Uganda). This was a significant benefit as the young farmer was found to be less interested in engaging in the face-to-face trainings. This is primarily driven by cultural norms of hierarchy surrounding elders, which demand a level of respect from youths. If an elder is present within the training groups, the younger farmers are discouraged from asking questions or speaking up in the sessions. Social media platforms thus hold the opportunity to become spaces where hierarchies and control of youth are redefined or removed entirely. Thereby increasing the inclusion of all farmers and facilitating their collective access. This is made even more achievable by the fact that the younger generation show a higher interest in tools that are more digital-forward. They want to be on and using these digital platforms. However, this does not mean that the older generation has to be excluded from this space either. While older farmers have shown a preference for calls, perceiving them to be more trustworthy and interactive. WhatsApp can appease some of these needs, as it has the addition of a mobile hotline for the farmers should they wish to call in and ask questions. Therefore, making social media a useful tool for facilitating inclusion and access.

(3) Mobile Learning Apps

Of all the digital mediums utilised by the Knowledge Transfer, mobile learning apps were the most under-explored and underdeveloped. The Nigeria team was making the most advancement with the platforms having recently piloted an app called Funzi, which focused on providing the farmers with step-by-step learning in seedling production. With Funzi there were a number of aspects that needed to be addressed to ensure its inclusivity for the main stakeholders, farmers. The first barrier was affordability, "a lot of these mobile apps, it is the airtime of the farmer that they are going to use. And if the airtime is too expensive, then it is not feasible" (Head of Knowledge Transfer Africa)

The Knowledge Transfer Team was able to reduce the costs of the app to around \$1 per farmer, making the platform adoptable for the farmers outside of the pilot study. The app

was also usable on a feature phone as well as a smartphone, ensuring its accessibility for all levels of smallholder farmer. The original content supplied by Funzi was reviewed by the Nigeria team's Working Technical Group to ensure that the training was suitable for the farmers and aligned with their level of (digital) literacy. Furthermore, the content was translated into the local Hausa language to make it understandable for the farmers. The high participation rate and response to the pilot certainly indicates its inclusivity for younger, educated farmers in particular. This indicated the app's ability to facilitate communication with the farmer and offer extension services using digital learning. The app also allowed the farmers to learn on their own, which greatly increased the Knowledge Transfer's capacity to reach a wider audience of farmers.

However, a significant drawback to inclusivity for mobile learning apps and social media was the low penetration of smartphones as well as the affordability and access to internet or mobile data. The Knowledge Transfer was aware of both the low penetration and affordability and placed more focus on images and gifs as opposed to data-heavy videos. This did come at the cost of videos interactivity, perception of trust and sensitivity to illiteracy. For farmers to gain the most impact from digital services, mobile networks need to be reliable, available, and most crucially affordable. But this requires a larger structural transformation within the countries. As the Knowledge Transfer Manager in Tanzania explained,

There are issues that you cannot do alone as an island. So sometimes we have to work with the different partners to make sure that we put the concerted efforts to see how it goes because you need the entire value chain to be engaged to make sure that at least you move.

An interesting finding from the data showed that there was a greater acceptance of the Knowledge Transfer's trainings on the digital platforms after it had been endorsed by the government extension workers. This is a finding that has been echoed in other studies that found farmers acceptance and continued use of a service was greater when it had been endorsed by their social network (Porciello, et al., 2020). The social network within which the farmers operate, therefore, holds much potential to help facilitate further inclusion and adoption of the digital media offerings.

As was perhaps to be expected, the majority of participants in the pilot study were young farmers, with most under the age of 35. Moreover, most had a completed secondary education, and a high proportion owned a smartphone. From the discussion in the social media section, it has been shown that this is largely due to younger farmers higher level of

digital literacy and comfort using new technology. These findings are exciting as they show an effective means for engaging young farmers and facilitating their desire to learn outside the traditional face-to-face trainings. However, a more worrying finding was that 77% of the participants were men. It is understood that due to cultural constraints women often have less access to mobile phones. But the concern here is that if an active effort is not placed by the Knowledge Transfer on formulating inclusion along gender-based or collective terms, women will continually be excluded from participating in the organisation's innovation process.

4.3 Use of Digital Media for Response to Challenges

Within Rose & Chilver's (2018) conception of responsible innovation, the dimension of responsive can be understood as the ability of the innovation process to adapt quickly to changing problems of the stakeholders. From the data it is clear that smallholder farmers in sub-Saharan Africa are facing an overwhelming number of challenges that are often out of their control and require them to adapt quickly. These problems include changes in climate conditions, poor or underdeveloped infrastructure, fluctuating support from the government, lack of access to markets, capital and land and a wider gap in knowledge on sustainable and resilient agricultural practices. The GAP and management training offered by the Knowledge Transfer aims to fill in and help farmers compensate for this lack of access and knowledge.

However, the organisation faces the issue of not enough boots on the ground, and so not enough farmers are able to receive the benefits of these innovative practices. An issue that is further aggravated by lack of advisory extension services from the government, the traditional means of delivering information inputs to farmers (Deichmann, Goyal & Mishra, 2016). In Uganda, for example, only 19% of farm households report engagement with extension workers and Nigeria the ratio of extension workers to farmer is estimated to be around 1 to 10 000. In some cases where farmers have the opportunity to engage with the extension officers, many are not informed on the proper production of vegetables. This is in part due to the local government's focus on staple crops such as cereals, maize, and rice for food security. "So vegetables in Tanzania was assumed as the backyard, is something you put on your garden... And they did not know that vegetables are high value crops" (Knowledge Transfer Manager Tanzania). All of which further increases the information asymmetries within the sector. From the analysis all three of the digital media tools used by the Knowledge Transfer appear to provide farmers with a means to get relatively instant

access to advice to help them overcome the above barriers and respond to structural challenges.

(1) Radio

Radio was found to be responsive to the challenges faced by smallholder farmers, in particular that of climate resilience, changing environmental conditions and access to inputs. In one example, the Technical Officers in Nigeria explained how they had recently adapted their content to support farmers and the government in the outbreak of the Tuta Absoluta moth, a pest that targets tomato plants, one of the most frequently grown crops amongst smallholder farmers. The radio anchors provided information on the proper use of pesticides and practices for combating the outbreak. In so doing, they gave the farmers updated information and the space to exchange information, which allowed them to cope with the outbreak and benefit from a change in farming practices.

This tailoring of content within the radio programmes was also shown to help farmers adapt their practices to different seasons. In Uganda, Tanzania and Nigeria, there are two principle growing seasons, rainy and dry. The rainy season can pose a number of challenges for farmers, particularly as climate change has brought with it more extreme conditions such as flooding. From the discussion with the Technical Team Lead Tanzania, it was indicated that many farmers refrained from growing in this season “because they fear about the challenge of diseases, and they don't want to incur costs.” As a result, the farmers lose out on a potential harvest and profit. The Knowledge Transfer team, therefore, catered their radio training to the change in weather patterns in order help farmers develop a resilience and benefit from the crops grown in both seasons.

A further adaptation of the innovation process seen in the radio programmes was noted in terms of agricultural inputs and their availability within certain regions. Plastic mulch for instance is an effective input for helping plants to retain moisture in the soil. East-WestSeed had much success with it in Asia and as a result it was advocated to the African Knowledge Transfer teams. However, in both Nigeria and Tanzania upon application, plastic mulch was found to be too hot for the plants, in most cases killing them. Moreover, there was also a cost implication whereby most farmers were not able afford to buy the plastic mulch or indeed in some cases access it though their local agro-input dealer. "We tried to look around for locally source material... because if you introduce a technology and then thereafter the farmer cannot even access or afford it, it becomes a learning exercise with no adoption" (Business Development Manager). Traditional organic mulch was found to be cheap, accessible, and beneficial to the plants, and had the added benefit of increasing fertility of

the soil once it decomposed. As a result, organic mulch become the new default recommendation within the radio programmes and other trainings.

Extension systems that continue a business-as-usual approach have been found to have a low usage amongst farmers (Deichmann, Goyal & Mishra, 2016). This is often due to their promotion of technologies that are unprofitable, because of high costs or lack of obvious benefits for the farmer. The Knowledge Transfer's quick adaptation of their process to meet the farmer's challenges is certainly promising and indicative of a responsive mindset. However, while the radio programme arguable strives to keep the farmers informed on the best GAP practices, the instance of the plastic mulch demonstrates that farmers may not necessarily be able to act on that information because of inaccessibility to alternative options. This point that should be kept in mind for the design and application of all the organisation's innovation processes.

(2) Social Media

In terms of responsiveness, Facebook and WhatsApp, particularly in the form of the farmer groups, were found to be highly effective in helping farmers adapt to the problems posed by poor infrastructure. As the Knowledge Transfer Manager in Uganda explains, "infrastructure has a direct link with agriculture - if it's not well developed, they can't transport their produce and vegetables are perishable". Moreover, lack of infrastructure results in poorly integrated agricultural markets, with brokers based in city centres unable to connect with rural farmers to sell their produce. Opportunities for farmers to make sales are then confined to dry seasons when brokers are able to access roads. But as the interviewed Tanzania farmer had experienced, in rainy season "there is high rainfall, so it is difficult for a motor, some cars, brokers to come and collect the produce". Often resulting in high search costs for brokers as they are required to move from one farmer to another filling their trucks with the required volume of produce. "So, in the end, they have to lower the price because of moving from one point to another point" (Knowledge Manager Tanzania). This in turn lowers competitive prices for farmers and leads to an inefficient allocation of goods across markets (Deichmann, Goyal & Mishra, 2016).

To respond to these challenges, farmers need to coordinate on the crops grown in their area to provide brokers with volume of produce and attain a good price for their crops. From the findings, the Knowledge Transfer's social media platforms helped to facilitate a social network of farmers using Facebooks groups, which then allowed them to collaborate on choice of crops. Thus creating assurance and maintenance of stability for the businessman or trader buying the produce. In so doing, this ensures that the trader only needs to come to one

area to buy a suitable volume of onions for example, allowing the farmer to sell their produce at a reasonable market price.

In addition, the Knowledge Transfer shared market forecasting information on these platforms, which further helped to improve the farmer's sale of produce. As explained by the Project Coordinator Nigeria, "sometimes farmers produce crops that are not actually the crop that markets require at that point in time... then they sell it too cheap because they cannot process some of these perishable crops". The organisation also shared market prices on the social media platforms, in particular the WhatsApp groups. This helped to further reduce the information asymmetry between middlemen and farmers. In the report from the Deichmann, Goyal and Mishra (2016), middlemen were shown to be typically the most informed on market prices, which would often lead to the exploitation of farmers. As the farmers had no idea of the market value of their produce, middlemen could demand drastically different prices for the same product. This may lead to loss of income for farmers and a higher price for consumers. These social media groups then can also inform farmers on the market price of certain produce, reducing traders' abilities to take advantage of the farmers, as well as forecast the types of crops being produced to reduce the chances of a glut in the market.

However, while these findings are encouraging for farmers, if these digital investments and innovations are not accompanied by long overdue reforms in business regulations, infrastructure and public sector governance, their ability to continue responding to farmers needs will fall short. Technology can only go so far in addressing the barriers faced by farmers in resource-constrained countries. For the Knowledge Transfer then an area worth investigating to further to improve the responsiveness of their innovation processes is how to create better linkages between middlemen or brokers and farmers. This will likely benefit the entire agricultural value chain.

Social media also proved to be a cost-effective means for creating an engaging learning environment especially for youths. The majority of the Knowledge Transfer followers across all three countries were between the ages of 25-34. As was mentioned in the previous section, young farmers enjoy and engage with novel tools that social media has to offer. Indeed, as the Knowledge Transfer Manager Tanzania found out for himself when he used Facebook Live to broadcast a field day.

I connected the Facebook Live for the event, projects, and questions. There was a big reaction from the youth that are following me... And after that one I received a lot of phone calls. it was good. 'I hear someone explaining this one. That complaint from that farmer, I'm also fixing that one. 'It was really nice for me.

The range of this broadcast would have reached a much higher number of farmers than the in-person field day. If all the Knowledge Transfer field days are broadcast using tools like Facebook Live, more farmers will likely learn about the organisation's practices. In so doing this will also reduce the costs that come with the technical officers travelling to visit farmers. It is estimated that using mobile phones has the comparative cost of one-fourth of the price of a visit (Aker, 2011).

Although, it must be noted that while the online platforms are effective in engaging farmers and facilitating learning. One of the interviewed Tanzanian farmers, for instance, learnt about hybrid seeds and the requirements of different environments through Facebook content on the Knowledge Transfer's page. These platforms are "not as effective as one on one training as [the farmers] don't have the opportunity to ask follow up questions or look at field (Project Coordinator Uganda).

(3) Mobile Learning Apps

The mobile learning apps principally aided the Knowledge Transfer innovation process to respond to farmers needs for information tailored to their specific context, easy to access technology and flexible applicability of learnings. The Funzi course was focused on teaching farmers about quality seeds, use of improved open bed seedling production and cellular seedling production. From a baseline survey conducted before the initiation of the pilot project, these three aspects were identified as significant gaps in knowledge for the farmers. More importantly, as explained by the Business Development Manager, with the range of offered learnings "[the Knowledge Transfer] try to expose the farmers to different technologies. It's not mandated to adopt all. He sees which one is easier for him". Thus, the farmers ability to leverage the technology within their skill capacity helped make them more receptive to the course. A finding that can be seen in the post-course survey, which showed 93% of participants felt they could apply the knowledge they gained to their farm.

The success of the Funzi pilot has driven further exploration into two other mobile learning apps, Kucheza and Arifu which would allow the farmers to respond to other challenges such as lack of market and business knowledge or land management and even appropriate input application. The platforms would also assist the Knowledge Transfer in improving farmers knowledge of savings and investments, and thereby their ability to respond to the challenge of lack of access to capital. Typically, farmers would use the entirety of their proceeds from their last cultivation to spend on household necessities, food, medicine or in some cases as the Technical Coordinator in Nigeria explained, to "go marry additional wives". The resultant lack of capital would often lead to farmers abandoning fields or buying cheap inputs that then compromised their produce. These mobile apps,

therefore, are a promising tool for facilitating responsive innovation process. Much like with social media and radio the content can be continually updated to respond to farmers changing environmental needs. The app's combination of voice, text and internet can also be useful for suitably replacing in-person visits from technical officers and thereby reduce the transaction costs associated with trainings. Allowing the Knowledge Transfer more budget to increase the frequency of their interaction of farmers across a wider distance and scale up the projects.

4.4 Digital Media Creates Data for Reflection

The dimension of reflexivity according to Rose & Chilvers (2018), requires that opportunities are created within the innovation process to assess the trajectories of the innovation and whether these are mutually benefiting for all stakeholders. The advantage of digital technologies is their ability to easily collect data for later analysis and reflection. Of particular use are the points of interaction between organisations offering the innovation and the end-users either through comments, surveys, or reviews left on the digital platform. From the findings it can be seen that the Knowledge Transfer actively draws on this capacity to not only inform their content and trainings but also drive new innovations within their processes. Moreover, the organisation has created its own data collection app called the EWS KT CMS App, which allows the Knowledge Transfer team to collect data on demonstration plots, trainings, and evaluate the impact of these on the farmers livelihoods.

(1) Radio

In the context of the radio programmes, reflexivity was primarily facilitated through farmer feedback on phone calls and surveys. Due to the nature of radio, it is difficult to measure the impact of the programme and allow the innovator opportunity to reflect on if their approach is achieving the intended aim (Long, et al., 2020). For instance, the radio session conducted in Tanzania is estimated to reach 653 959 people in the areas of Iringa, Dodoma and Njombe. However, the Knowledge Transfer's radio programme somewhat overcomes this obstacle by facilitating calls and text messages on their radio programme. Farmers appear to regularly call in and testifying their results from applying the practices they had learnt from the radio programme. As one Technical Field Officer from Nigeria explained, "the number of calls that we are receiving during and after the radio programme is enough reason for us to know our farmers are impacted". This feedback allows the Knowledge Transfer to have some degree of reflection on their innovation process.

In terms of surveys, these are conducted in the farming communities and focus specifically on the radio programme. As a result, they were also found to be a useful tool for

reflection on both impact and aim. At the time of data collection, the Nigerian team were currently undertaking a survey for just such a purpose. In some cases, these surveys would be conducted by a university as an external evaluator of the project's impact. An outcome of these opportunities for reflection seen in the internal document analysis was the realisation that more creativity was needed in the digital media content in order to engage farmers. Suggestions of improvement included quizzes on previously discussed topics and interviews with farmers.

(2) Social Media

The opportunities for reflection and reflexivity within the social media platforms stemmed largely from the farmer feedback received via comments as well as each page's monthly analytic reports. As explained by the Knowledge Transfer Manager Tanzania, "those comments also help us to improve the way we do our activities". From the internal document analysis for instance, a review of the social media content has shown the top performing posts, which has allowed the team to adapt the content to what the farmers want to engage with. Findings have shown that in Nigeria that farmers want image-based posts that show the demonstration plots and more market and price analysis posts. In Tanzania, farmers have shown a preference for technical guides on how to use agricultural inputs. In Uganda, this reflection has assisted the team to create different social media avenues to improve their indirect outreach and in so doing have attracted over 4 000 followers to their Facebook page within six months. This farmer feedback, therefore, appears to hold much potential for the Knowledge Transfer to assess their innovation process trajectory and adapt it to be more effective and responsible.

However, from the findings there was little indication that the Knowledge Transfer was spending reflective energy on addressing the high disparity in numbers between male and female followers. Across all three countries, the proportion of male followers was significantly higher than female followers, with women sometimes accounting for less than 30% of a page's following. Data on the gender distribution within the WhatsApp and Telegram was not available but considering the data from the other social media platforms it is likely to be a similar spread. Taking into consideration that external structural barriers are a significant cause of this disparity, there is still an opportunity here for the Knowledge Transfer to reflect on and address this issue.

(3) Mobile Learning Apps

Reflection of the Funzi app's impact and the extent to which the innovation aims were achieved was facilitated by a post-pilot survey. As explained by the Head of Knowledge Transfer Africa, "for the big projects, what we do is either in terms of midterm or at the end

of the project, we actually do an evaluation with an external consultant”. A finding of particular interest from the reflection was the role of the organisation to reduce the gender gap for mobile app usage, as only 22.1% of the respondents were female. This realisation helped encourage the organisation to ask how appropriate the technology was for the farmers they were working with.

Other points of reflection that were of interest included that there were an almost equal number of farmers participating in the pilot study who had previous involvement with Knowledge Transfer compared to those who had not worked with the organisation before. This suggests that the farmer’s social networks were highly effective in advertising and spreading the word about the course to each other. Moreover, that there was a level of perceived trust and credibility for the Knowledge Transfer’s practices even for outside farmers. This likely would have been further enhanced for future pilots by the fact that 90.7% of participants who did not grow vegetables prior to taking the Funzi course, would now consider doing so. There was also a high rate of conversion of farmers in the course who would now use commercial seeds as opposed to traditional saved seed methods. All of which suggests that the Knowledge Transfer’s approach in the mobile app was effective for the innovation process.

A final finding of interest from the survey reflection was that many farmers requested a hard copy of the course for later referral. This may suggest some hesitancy with using digital technology on the part of the farmer. Moreover, that perhaps some repetition of practices within the course is necessary to allow farmers to feel comfortable and familiar with the techniques.

(4) EWS KT CMS App

The EWS KT CMS app, also referred to internally as the CMS app, is a data collection tool created by East-WestSeed to assist the Knowledge Transfer teams in monitoring the practical outcomes of their activities and evaluating their impact. In so doing the aim is to drive better management, better planning, better decision making, and the more effective and efficient use of resources within the innovation process. Currently the app is focused solely on the demonstration plots, trainings and the Return on Investment (ROI) of these activities. As of yet, their digital activities are not being monitored in the app, which is perhaps a space for future adaption to further improve their reflective capabilities.

The app’s limited but focused collection of data on the projects including seeds, crops, approaches, constraints as well as the social factors of farmers including age, gender and location, makes the app an exciting tool for reflection. Here the Knowledge Transfer team can evaluate the cost and returns of specific inputs or the profit margin of crops amongst

other factors. All of this which improves their ability to refine and adjust their processes to drive further innovation within the sector. A useful reflection of some of the data in the app for example showed that the cost of an input was often the cause of farmers not adopting a technique. It also helped the Knowledge Transfer identify gaps in knowledge amongst farmers, for instance the most popular training modules were record keeping and cost/return analysis. Such findings give the Knowledge Transfer the opportunity to introduce more of these courses or adapt their techniques to improve farmer adoption.

Findings from Uganda, for instance, indicated that the use of improved seed, soil and water conservation techniques like planting in raised beds and use of organic mulch were easily adoptable techniques for farmers as they required minimal skill to implement. More complex techniques such as like raising seedlings in containers and diagnosing to select appropriate pest management practices were far more challenging for farmers and therefore perhaps an opportunity for more training from the Knowledge Transfer. In Tanzania, other findings from the CMS tool shows that a farmer's selection of a crop and its variety depended on market demand and the consumption of the crop within the family or farming area. Here, the suggestions from the Technical Field Officers could help inform farmers' choices and introduce new varieties to growing areas, helping the Knowledge Transfer to improve the sustainability, impact, and perhaps even scale of their projects.

A further exciting finding from the analysis of the external documents, showed that a tool such as the CMS app was currently missing from the global digital agricultural landscape. The coordinated collection of data such as that done by the CMS app could help establish a framework of common globally owned practices for the sector. In so doing it will help monitor how the agricultural field is progressing. This becomes even more important for social factors such as gender, wealth even cultural norms, which are currently under researched and missing from much of the data collection in other studies (Porciello, et al., 2020). Findings from the CMS app for instance showed that only 19% of key farmers are women and 40% of organisation's trained farmers are women. In addition, limited land ownership rights in the West Nile and Northern regions of Uganda were attributed as the cause of fewer women hosting demonstration plots, 5% in comparison to the 95% of men.

These findings assist the Knowledge Transfer to reflect on the need for gender mainstreaming in their activities and greater mobilization of women to attend trainings. The CMS tool, therefore, could serve as an enabling environment to identify and remove long entrenched barriers within the sector. If of course, the Knowledge Transfer was open to sharing the tool with other organisations.

4.5 Impact is Positively Anticipated

The final dimension of Responsible Innovation is anticipation, which entails the forecasting of an innovation's impact at all scales of the value chain (Rose & Chilvers, 2018). It is typically understood as a precautionary approach to consider consequences that promote vigilance, informed by historical experience and imagination (Nordmann, 2014). When an innovation is undertaken, it will most likely have both a positive as well as negative impact. Yet, from the data analysis, the Knowledge Transfer team spoke predominately of the positive impacts of their innovation for the farmers. The social media pages and groups were anticipated to have outcomes such as bettering farmer development and improving their production capabilities. Informants spoke enthusiastically of the increased awareness that the radio programme will bring to vegetable production and the improvement of maximising profit and minimising production cost. Even within the demonstration plots, which arguably have the most focus within the Knowledge Transfer activities, the negative outcomes were not overtly highlighted. For instance, when discussing the host selection criteria for demonstrations, the internal documents showed an anticipation for how the proper selection will ensure the plot's accessibility and attractiveness to neighbouring farmers and the resultant increase in farmer adoption of practices. Yet there was no discussion on anticipated negative impacts of the selection.

Indeed, only one instance was identified within the data where the Knowledge Transfer anticipated a negative impact of their activities. This was done by the Head of the Knowledge Transfer Africa, who raised concerns that too much emphasis on the mobile learning app may impact the disparities of gender inequality within the farming community in Nigeria. As he explained,

If we emphasize that we have piloted Funzi mobile learning, if we emphasize it too much in those particular communities [in Northern Nigeria] we are also doing a disservice to the women. So let us utilize radio which they are able to access.

The dimension of anticipation is, therefore, an aspect that requires far more attention from the Knowledge Transfer team if they are to achieve responsible innovation within their processes.

5. Discussion & Conclusion

This investigation focused on a case study of the hybrid seed developer East-West Seed's operations in Uganda, Tanzania and Nigeria. More specifically the activities conducted by its non-profit division, the Knowledge Transfer. This branch of the organisation was established to upskill farmers in Good Agronomic Practices (GAP) and develop their farm management knowledge. In so doing, the intention is to “supporting [the] farmer to support himself, giving him skills rather than giving him items” (Project Coordinator Uganda). The aim of the case study was to answer the following research question: *how do agricultural organisations create responsible innovation using digital media within the farming sector in sub-Saharan Africa*. To help guide the investigation this study also aimed to answer the following sub-questions: *how can digital technologies be leveraged to support contemporary entrepreneurship in the agricultural sector of sub-Saharan Africa?; and What are the organization's understanding of responsible innovation in their sector and the challenges and opportunities of shifting their business to be more ethical, sustainable and resilient?*

From the findings it was shown that two processes of innovation were taking place. The first was the Good Agronomic Practices (GAP) offered by the Knowledge Transfer to farmers through in-person training programmes. The second was the organisation's use of ICTs, specifically mobile phones, radio, and internet as complementary modalities to the training programmes. Of most significance here was that within both these processes so called ‘lower’ innovations were being applied and used within the sector to stimulate radically transformative results. For instance, the GAP techniques consisted of tried and tested methods such as the use of trellising for growing tomatoes, drip irrigation and raised seedling beds. While these techniques are not new within agriculture, within the context of these smallholder farmers, they were novel and innovative. This also extended to the organisation's use of radio and mobile phones as the primary digital technologies to facilitate the innovation processes. All of which were able to assist farmers in overcoming structural barriers such as lack of access to capital, knowledge about markets and farming practices, government support and poor infrastructure. This finding points to a need within agricultural organisations to shift their focus from the belief that only ‘higher’ innovative technologies hold the solution for the challenges faced by the sector.

Focusing first on the second sub-question, *what are the organization's understanding of responsible innovation in their sector and the challenges and opportunities of shifting their business to be more ethical, sustainable, and resilient?* To ensure an innovation is

responsible, the process must be open, interactive and consider the needs of societal actors as well as the innovators (Rose & Chilvers, 2018). This can be facilitated by ensuring that the process is inclusive of all affected stakeholders, responsive to problems, incorporates opportunities for reflection and anticipates the innovation's potential impact.

The primary challenges faced by farmers for inclusion into an innovation process were access to technology and gaps in knowledge. For smallholder farmers access was facilitated by ownership of land, proximity to demonstration sites, radio, and mobile phones. The Knowledge Transfer was aware of the challenges faced by farmers, which were mainly structural barriers such as lack of access to capital, knowledge about markets and farming practices, (digital) illiteracy and poor infrastructure. As a result, to facilitate a greater inclusion of smallholder farmers and properly address their needs, the Knowledge Transfer made a significant effort to reach a range of farmers using different digital platforms and adapt their approaches to suit farmers' contexts. This entailed offering trainings in local languages, incorporating more imagery and seeking out their input on what they would like to learn about. The Knowledge Transfer actively included the farmers into the innovation process by facilitating their participation at all stages of the innovation process, by involving them in the development of the training approaches and encouraging their active influence through direct engagement with the Knowledge Transfer team. In addition to the primary in-person trainings, the Knowledge Transfer employed radio, social and mobile learning apps to reach a wider audience and engage a younger audience as well. Other key stakeholders were also included into the innovation process with NGOs informing training approaches at the initiation stage, local universities serving as sites for the demonstration of the innovation as well as training agro-input dealers, farmer groups and government extension officers to inform and support the approaches

However, the findings also showed that the Knowledge Transfer faced a challenge for the inclusion of female farmers. Across the digital platforms, women accounted for a small percentage of active agents. There was some indication that the Knowledge Transfer was adapting their approaches, including the creation of female-only training groups and a focus on kitchen gardens for women who were not able to go out into the field. But here overlapping social factors like education and status created an interdependent system of discrimination and disadvantage. A greater understanding of their complex role within agriculture is essential to fostering responsible innovation, especially in areas such as Northern Nigeria where cultural constraints further complicate their role.

Smallholder farmers face several ongoing challenges that make it important for an innovation to be able to responsive to problems. These challenges include changing climate

conditions, outbreaks of pests and diseases, access to inputs, variable government policies and unreliable vegetable markets. From the findings it was shown that digital media, especially the radio, were highly effective for ensuring that the Knowledge Transfer innovation process could respond to these problems. The trainings offered through the radio programmes were continually adapted to suit the context and situation faced by farmers at the time. This was also seen in the content on the different Facebook and WhatsApp groups. The service design of the digital media gives farmers almost on demand access to advice and learnings to guide their production and decision-making, ensuring its relevance to the farmer's priorities and constraints. As a result, helping to drive as well as sustained adoption of the technologies.

However, as can also be seen from the analysis of the data, connectivity and access to technology still remain significant barriers for the farmers. This is largely driven by poor infrastructure and the farmer's limited resources. The solutions to these issues require a fundamental and widespread structural transformation within the sector that cannot be achieved by the Knowledge Transfer alone. Progress within digital media's use and application within the sector will, therefore, be highly interdependent on creating an enabling environment based on removing long entrenched barriers.

Farmer feedback through surveys, interviews and the organisation's CMS app served to facilitate continual reflection on the activities as well as their trajectories. All of which assisted the Knowledge Transfer to make adaptations and improvements to their training and digital offerings to meet farmer's needs. In addition, digital media's built-in data collection tools were found to be highly beneficial for the organisation to draw on and reflect on their approaches. The findings of the study show that social differences are essential for understanding the use of digital technologies and services by the farmers. Age, education, wealth and most significantly gender were all influential and impactful on the farmers use of the digital media offerings. A farmer's education level has a significant positive influence on the use of agricultural technology (Porciello, et al., 2020). Their motivation to use a service has also been linked to their perception of its benefit and if it is worth the effort.

Of concern though is the lack of focus from the organisation on anticipating potential impacts of their innovation. Most especially the negative impacts, which was seen in the findings. The addition of this dimension within their innovation process, will assist the Knowledge Transfer in facilitating an innovation that is more ethical, sustainable, and resilient.

Now focusing on the first sub-question, *how can digital technologies be leveraged to support contemporary entrepreneurship in the agricultural sector of sub-Saharan Africa?* It

was clear from the findings that the future of agriculture is digital. The digital media tools employed by the Knowledge Transfer team, were shown to have greater reach, improved cost effectiveness and have significant opportunities for growth and cost-savings for both the organisation and farmers. Farmers were shown to be able to use their mobile phones to collaborate with other farmers and connect with brokers to create better market linkages and improve their business operations. Radio and mobile phones also assisted farmers in keeping up to date with new practices and opportunities. Digital technology is, therefore, clearly changing the agricultural landscape. Mobile phones have increased access to information, knowledge, financial services, markets and farm tools for farmers across the continent. Yet, access is still not equitable with only 47% of the population in sub-Saharan Africa able to access electricity and a mere 45% mobile phone penetration in the region (Porciello, et al., 2020).

However, before this study gets carried away by the myth of the ‘digital sublime’, (Cobby, 2020), it is also clear from the analysis that these digital media have not been able to automatically, positively and meaningfully address the complex environment of agriculture. It is of interest that there was little concern from the farmers over data-sharing and privacy. An area that is certainly coming under increasing scrutiny for its ability to create problematic and unequal power distributions within the sector.

Therefore, this study has shown that for an agricultural organisation to create responsible innovation within a complex environment such as sub-Saharan Africa it must first gain a comprehensive understanding of who are their stakeholders, what challenges they face and the opportunities their innovation process can create. Next the organisation must employ a wide range digital media platforms to cater and tailor their innovations to the specific context and needs of their stakeholders. Furthermore, these digital media can be used to collect data for reflection on their trajectories and further evaluation to assist in the anticipation of future impact.

5.1 Limitations & Future Research

This study has a number of limitations that stem from the unique characteristics of case study analysis. First and foremost are the issues of validity that are related to a single researcher collecting data in the field alone, the focus on describing the findings and less on how they were reached as well as the limitations in processing the collected data. To guard against this bias, a concerted effort was made by the researcher to develop a framework prior to data collection to guide the process as well as the analysis. Furthermore, a conscious effort was made to ask problem-orientated questions and search for negative evidence to

provide balance within the findings. However, future research may benefit significantly from the addition of researchers within the study to further minimise inherent bias through the corroborating findings.

While an active effort was made by the researcher to ensure that the data sample was representative of the larger population there was a skew within the sample towards management, which may have affected the types of responses within the interviews and focus groups. Furthermore, only two farmers were interviewed on their experience, and this was facilitated through a translator. This may have impacted the responses received as information may have been lost in translation. Future research would do well to incorporate a larger sample group, especially of the farmers, to gain a wider perspective and have the participants check each other's findings.

Reliability within the study also served a significant limitation. Reliability is focused on the consistent replication of the study itself as well as its outcomes. Within qualitative research some degree of difference in findings is expected but the researcher has aimed to address these issues by outlining the framework, sampling and data collection procedures as well as analysis in detail. However, this study's analysis of a single case does limit its generalizability as an illustrative example. Future research therefore should expand the number of cases analysed to improve the generalizability of the findings. A wider data set of more African countries would also increase the understanding and evaluation of how digital technology is progressing within the agricultural sector.

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