The role of digital technologies in enabling subsistence farming in rural KwaZulu Natal

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Abstract

Food security has grown in importance over the years, ranking among the world's most pressing issues. High food demand has led to poverty, yet sustainable food production methods have proven effective in reducing it. Because of both macro and micro environmental factors, the adoption of digital technology in agriculture have recently had a significant impact on the global landscape.

Digital technologies are assisting in meeting the increasing need for sustainable food production on a worldwide scale. This has been achieved by incorporating several digital technologies such as robotics, automation, sensors, Internet of Things (IoT), and data analytics into agricultural processes to maximize crop yields, lower emissions, and optimize farming inputs. By allowing the traceability of goods and processes, this can enable transition from hard human labour to continually automated processes and thus improving agricultural productivity.

This study aimed to investigate how digital technologies can enable subsistence farming in KwaZulu Natal. A qualitative approach was adopted for the research, thirteen participants who were subsistence farmers were interviewed using open ended questions. Thematic approach was used to analyse the findings.

The findings revealed that adoption of digital technologies was still in its infancy stages, and this was attributed to socio-economic factors such as lack of digital skills, lack of capital to purchase and maintain farming technologies, access to reliable power sources and water. Incorporating technology into farming practices could lead to innovative farming in the rural communities of KZN who still practice conventional farming methods. By applying digital farming technologies, farmers can obtain precise and up-to-date observations on several factors impacting their yield, including plant health, soil quality, meteorological conditions, and the prevalence of pests and diseases. Digital technologies assist agricultural

producers and academics to make better judgments by analysing the findings. Data obtained can enhance productivity, cut expenses, and oversee resources.

Though unevenly, Southern Africa has been rapidly going digital. But the revolution that digitisation promised has not yet materialised in the food and agriculture sectors. Even if these technologies may still be in their infancy in Southern Africa, policymakers must have a forward-thinking mindset to foster an atmosphere that encourages the usage of digital solutions. Encouraging regulations, infrastructure, expertise, and government assistance will be critical in building the foundational elements required to enable DT in agriculture to flourish. It is important not to undervalue the importance of straightforward, useful, and relevant digital tools in African agriculture, particularly when interacting with farmers in rural arears.

Keywords

Digitalisation, Digital Technologies, Agriculture, Subsistence Farming, Rural KwaZulu Natal, Unified Theory of Acceptance and Use of Technology

Dedication

This work is dedicated to my family, Sbusiso, Khulasande, Bandile and Sbusisiwe Zulu. Thank you for allowing me to be myself and pursue my dreams. It was a long two years, you encouraged me and gave me all the necessary support. I truly appreciate you and love you.

To my friend Lindiwe Jokazi, thank you for everything, from calming down the anxiety to meals and lots of sugar when I needed it. I appreciate you.

Finally, to myself. Thank you for showing up even when it felt impossible, you stayed the course and got to the finish line. Well done, I’m extremely proud of the woman you have become. Keep reaching for greater heights.

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Finally, I thank all the Master's groups, thank you for staying the course, we have made it this far.

Declaration

I, Mamakhethe Flora Zulu, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Management in the field of Digital Business at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Name: Mamakhethe Signature: Mamakhethe Zulu

Signed at Midrand

On the 29th day of February 2024

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ADA **–** Agriculture Development Agency

CSIR **–** Council for Scientific and Industrial Research

ICT **–** Information and communication and Technology

IoT – Internet of Things

KZN – KwaZulu Natal

LSM – Living Standards Measure

NDP – National Development Plan

NSPF – National Stock Theft Prevention Forum

TAM – Technology Acceptance Model

UTAUT **–** Unified Theory of Acceptance and Use of Technology

CHAPTER 1. INTRODUCTION

1.1 Statement of purpose

This qualitative study explored the role of the digital technologies in enabling subsistence farming in communities in KwaZulu Natal. It further investigated the barriers to digitalisation in agriculture, and the interventions which could be implemented to enable technology adoption and increase efficiencies in rural agricultural practises to improve the livelihood of farming communities.

1.2 Background and context of the study

The agriculture industry in South Africa is crucial to maintain food security and generate jobs. Most of South Africa's rural communities still depend on subsistence farming as the primary source of livelihood for themselves and their families. (Siphesihle & Lelethu, 2020). Subsistence farming is when the sole objective of farming is for sustenance and not for commercial gains. It is an ancient practice and remains an enabler for economic growth and sustainability, providing nutrition, employment, and social status in rural South Africa. Subsistence farming is usually practised on small scale land hence it is also referred to as small-scale farming.

In 2021, South Africa had approximately 32000 commercial farmers, of which 12000 produce 80% of agricultural output. As consumers continue to restrict their budgets because of a contracting economy and increasing inflation, predictions indicate that the country's economic growth will stay suffocated. (*South Africa - Agricultural Sector*, 2023). Therefore, investing in agriculture is essential to attaining objectives relating to enhancing food security, generating income, creating jobs, and decreasing poverty.

South Africa's agricultural industry can be counted amongst the well advanced and diversified in Africa. Post Covid-19 pandemic agriculture sector continues to face increased difficulties such as climate change and heightened international rivalry. Socio-economic factors like increasing poverty numbers, and high unemployment rate, have been contributing factors to slow economic growth in South Africa, and therefore creating a huge concern for policy makers. According to the National Development Plan (NDP) agriculture industry has potential to generate one million jobs by 2030 (*HSRC*, 2023)

Over the last decade, digitilisation which is the use of Forth Industrial Revolution (4IR) technologies has revolutionised industries and agriculture has also been part of this transformation on a global scale. Digitalisation of agriculture can be seen as the integration of digital technologies such as Internet of Things (IOT), Big Data, sensors, robotics, Artificial Intelligence, drones, and others in effort to improve animal and food production (Tilson et al., 2010; Smith, 2018). Factors such as climate change and COVID19 pandemic have had devastating effects on agriculture and digital adoption has resulted in increased efficiencies, precision and improved yields and profits. Adoption of digital technologies enables internal and external interconnection creating a seamless flow of information. Large volumes of data can be analysed to give insights and as input in planning and decision making. This information can be easily accessible through digital tools such as smart phones.

Subsistence farming is mostly popular in the North-West and Eastern Cape and KwaZulu Natal provinces where the agricultural economy is dualistic, both highly developed commercial farming and more subsistence-based agriculture in the rural areas where the primary activities are mixed farming and intensive agricultural production (*HSRC*, 2023).

Land availability and ownership are key determinants on the type and the scale of agriculture that can be practised. Land ownership laws in South Africa are to a larger extend still informed by the political history of apartheid. There was unequal distribution and ownership of land, and the white citizens were the beneficiaries while the black population was marginalised. Development of South Africa's of subsistence farming should focus on rectifying the past unjust land ownership policies experienced under Colonialist and Apartheid rule (DAFF, 2016).

To unpack this research topic, it is crucial to understand the community of KZN and their investment as well as their attachment to their land, challenges in subsistence farming, analysing the internal and external environment, to understand the subsistence farming industry's weaknesses and strength as well as structure, the role digital technologies will play and complete by offering solutions and recommendations.

Figure 0-1 Map of KwaZulu Natal (KwaZulu Natal Hybrid Physical/Political Map, n.d.)

KwaZulu Natal is a coastal province situated in the southeastern part of South Africa with a population of 11.822 million people (Galal, 2022). In KZN province, there are 6.5 million hectares of land that may be used for agricultural purposes which 18% is arable and 82% is ideal for significant animal production. Although KZN comprises such a small amount of South Africa's geographical area, it is home to a sizeable proportion of the country's small small-scale farmers. (*KwaZulu-Natal Top Business | KwaZulu-Natal Agriculture*, n.d.) Agriculture in KZN is quite diversified and is related to topographic trends however, the sector has been severely impacted by irregular rainfall partners which have led to flooding and heat waves due to climate warming.

In KwaZulu Natal, a sizeable portion of land used for subsistence farming is owned by the traditional authority, Ingonyama Trust through customary law. Traditional leaders (Amakhosi) are the custodians of the communal land within their communities. (*Home*, n.d.) They are responsible for allocating land to community members for residential, agricultural practise or community development projects. Traditional leaders play the role of mediators in instances where there are land disputes. The communities do not own the land they occupy or use for farming, this is leased to.

1.3 Research problem

Agriculture is momentous in contributing to rural economic growth and ensuring food security (Masuku et al., 2017). This holds true to communities in rural KwaZulu Natal as they are to a large extend still reliant on traditional farming practices for their livelihoods. Having said this, the problem is that subsistence farming in rural communities is not fully maximised to play a strategic role of providing food security and facilitating rural economic development. These communities are faced with several challenges such as climate change, soil infertility, animal and crop diseases, access to markets and livestock theft. Livestock theft is one of the major challenges' farmers and communities face. Criminal syndicates mostly target subsistence and emerging farmers as they lack the resources to afford private security and do not have knowledge and access to digital devices which can monitor their livestock and farms. According to National Stock Theft Prevention Forum (NSPF), farmers lost more than R2 billion through stock theft over a one-year period between 2018 and 2019. The report further indicates that at least 15000 head of cattle, 500 sheep and 12000 goats, with a combined value of R165million, were stolen in KZN alone during this time. (IOL, 2020). Additionally, spatial planning in these communities was designed in the apartheid era when future areal development was not prioritised.

1.4 Research questions

The study addressed the following research questions.

1. What is the perceived value of the use of digital technologies, in rural KZN?
2. What benefits will digital technologies have on the community of rural KZN, and how will it contribute to improving agricultural practices and outcomes?
3. What are the perceived challenges of implementing digital technologies farming solutions in the of rural community KZN?

1.5 Rationale

Although communities in rural KwaZulu Natal have relied on subsistence farming as their key livelihood strategy for decades, they are still mostly poverty-stricken with elevated levels of unemployment particularly amongst the youth. Literature reveals that for all rural areas, the barriers that need to be addressed are:

1. Distance barriers, i.e., access to administrative and government services and structures,
2. Economic barriers, i.e., access to wider business and labour markets,
3. Social barriers of rural inhabitants' access to information, education and training, health, social services, etc.,
4. Traceability of production, products and services throughout the value chain including logistics (Stratigea, 2011).

This study is driven by the need to understand the current challenges which subsistence farmers experience and how these have become limitations to maximising the farmers resources and capabilities towards improving the farming practises and sustaining livelihoods. Enabling farming through adoption of digital

technologies in the rural communities will assist with crop and livestock management, with interventions such as disease management, breeding, and reproduction lifecycles. As literature has revealed that high rates of livestock theft are one of the main challenges in rural KZN, tracking and monitoring livestock using digital technologies such as IoT can save the livestock for these already struggling communities saving them money and time. Tracking and monitoring capability will also assist in curbing fatal accidents, which are mostly caused by stray livestock on provincial and municipal roads. Increased yield in crop production facilitated using digital technologies can mean that farmers will have a surplus and be able to expand the farming potentially practises into commercial scales. Conducting this study will create awareness about the use of digital technologies and influence perception about the use of technology in improving farming in the rural communities, creating sustainable jobs.

1.6 Definition of terms

Internet of Things (IoT): The use of digital equipment, connected items, embedded sensors, people, and systems to collect data through a telecommunications network without requiring human contact**.** (Gillis, 2023)

Subsistence farming: A type of agriculture in which the farmer and family consume all the crops or livestock produced, leaving barely any excess for trade or sale. Subsistence farming has always been a way of life for preindustrial agricultural people worldwide. As they depleted the soil at each location, some of these people relocated from one location to another. Farmers began to practice farming for profit as urban areas expanded. As a result, they produced large surpluses of specific commodities, which they either sold for cash or swapped for manufactured goods (Encyclopedia Britannica, 2016)

Rural: Settlement area that consist of the tribal lands controlled by traditional leaders. It is distinguished by low population densities, low levels of economic activity, and low levels of infrastructure, with agriculture serving as the primary economic activity. (S, Catherine, 2023)

Data: A collection of observations, measurements, study, or analysis results in data. Information, numerical data, names, figures, and descriptions of objects can all be included. Graphs, charts, or tables are used to arrange data. (Vaughan, 2019) Data can also be described as organised information that has value and can be used for decision making. Data needs to maintain accuracy, completeness and available when required. (2023)

1.7 Assumptions

- The participants will provide factual and objective information on the research questions asked.
- All participant who will be invited to be part of this study have sufficient knowledge and insights to contribute towards the study.
- Respondents who participated in the survey will be able to navigate the tool with ease and understanding.
- All potential participants will be receptive and willing to engage in subject matter.

1.8 Report Outline

Chapter one entails a brief background on the aim of the research on the role digital technologies can play in enabling subsistence farming in rural KZN. It also gives a detailed introduction into the past and present economic state of South Africa, and the role agriculture plays in the country's GDP. This chapter includes

Aim and Objectives, Research questions, Rationale, Statement of Purpose, Conclusion, and references.

Chapter two details the literature review, it also takes a dive into the aim of the research and discussion into how the role of digital technologies can improve agricultural practises in rural KZN. A thorough study into digital technologies and their standpoint in South Africa shows the reasons it is a viable option in optimising agricultural processes in rural KZN. It further details the risks and challenges likely to be faced regarding the current energy shortages in South Africa and how they can be mitigated.

Chapter three discusses the methodologies and data collection methods used and how they can assist in providing a 360 view into how the study could achieve success.

Chapter four discusses the results of the completed detailed analysis and research.

Chapter five finally details the findings and how they can be implemented.

Chapter six Conclusion and recommendations.

CHAPTER 2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

This chapter studies the body of knowledge which has already been documented relating to this study. A literature review demonstrates knowledge and grasp or a methodical method of compiling and synthesising prior studies. An efficient and well-executed review provides a solid framework for knowledge expansion and the facilitation of theory formation as a research approach. A literature review can address research topics with a power that no study can by incorporating the conclusions and points of view from numerous empirical findings. (*Literature Review*, 2022) The articles reviewed below cover the themes surrounding the research topic, including subsistence farming in rural South Africa, the role of digital technologies in agriculture, the potentials and shortfalls of digital technology and the adoption of digital technology.

2.2 Subsistence farming in rural South Africa

Subsistence farming plays a critical role in food and agriculture production to achieve a world free of hunger vision by 2030. (FAO and IFAD, 2019). According to Mugambiwa and Tirivangasi (2017) and Dwesini (2015), agricultural production is more important in rural areas of South Africa as it alleviates poverty and creates more job opportunities. (Siphesihle & Mdoda, 2020), Factors affecting subsistence farming in rural areas of Nyandeni local municipality in the Eastern Cape further reiterated that subsistence farming accounts for more than 90% of *the* food supply in the emerging economies.

In rural areas in South Africa, particularly KZN, subsistence farmers seem to have been left behind technologically. KZN has a population of 8,577,00 (21% of the

country's population),5,300,00 (62% live in rural areas), and 400,000 rural households that employ agriculture. (Anon 2023) This part of Southern Africa is synonymous with subsistence farming, which plays a significant role in food security. While this technological endeavour of enabling digital technologies in agriculture will be beneficial in this region with such large economies of scale, this type of agricultural upgrade has not been adopted. The industry is either concerned about the creation of technology infrastructure, or in the case where the infrastructure exists, effectiveness has not been established. In the reviews discussed below, we can gain understanding of previous research completed as well as analyse the data and limitations and further study how the outcomes could be used in our research to find suitable solutions.

According to Parfitt and Barthel (2010), subsistence farmers possess minimal technology skills and knowledge, which leads to slow technology adoption, high post-harvest losses, inferior quality products and low production levels. Lack of physical infrastructure network and technology infrastructure have become a challenge in adopting modern agricultural practices; therefore, digital technologies should be adopted to give real-time data, descriptive analysis predictions and results.

2.3 The role of digital agriculture (DA)

Digital Agriculture (DA) is the utilisation of modern tools, data monitoring and analytics, and data-driven solutions in agriculture for improved farming activities, while reducing waste, and managing pest and disease challenges. (Abiri et al., 2023).

Figure 2-1 The fundamental components of DA from cell phone to blockchain technology. (Abiri et al., 2023)

Agriculture must embrace the digital revolution if it is to prevent deterioration and extinction. Most earlier inventions used more potent and genetically efficient equipment. The employment of more sophisticated digital technology is currently necessary to reach the following phase of productivity growth. While innovative technologies are being developed, some instruments are presently at the disposal that could help farmers use them more effectively and intelligently. With the help of these new advances, decision-making can be improved, leading to increased risk and unpredictability reduction to maximise results and enhance profitability (*Agriculture's Connected Future: How Technology Can Yield New Growth*, 2020).

(Smidt, 2021), studied the factors that affect digital technology adoption by small-scale farmers in agriculture value chains (AVCs) in South Africa. The study focused on the role of governance and institutional support in enabling digital adoption. It revealed that institutions such as government, NGOs and legislative authorities should develop an AVC framework based on local conditions and integrate with regional, national, and global stakeholders. It highlighted that factors inhibiting digital technology adoption can be economic, social, and political. Rural farmers need to be ready and equipped to be part of the digital value chains. It also revealed that trust is essential in adopting digital technologies, subsistence farmers should be involved in the policy making processes. South African subsistence farmers have challenges with economies of scale because of lack of access to capital, minimal access to farming land and lack of technical knowledge and resources. (Malan, 2018)

2.4 Potentials and shortfalls of digital technologies

Abbasi et al. (2022) argue that digital technologies have positively transformed agriculture globally. Farmers have seen increased efficiencies, cost and time savings and improved resource management since adopting smart farming. Some benefits include automation which has improved processes such as harvesting, irrigation sowing, and pest control reducing time and labour effort invested into these processes in comparison to traditional farming practise. Real time surveillance and forecasting systems contribute to efficient use of resources, enhancing the agility of farm operations, and the saving resources such as water, money, power, and human capital. The study highlighted digital 21 shortfalls and categorised these into technical and socio-economic. Interconnectivity, data integrity and reliable power source, connectivity infrastructure, capital investment, law and regulation and digital division are some of the identified shortfalls for

digital adoption. This study is key to this research because it discusses elements which this study seeks to understand in answering the research questions.

Mulyana et al. (2022) examined the necessity of a device management scheme to simplify the process required to achieve installation, management, and maintenance of devices. The advantages accentuated were the different versions of IoT that could be utilised and how they could benefit different agricultural systems. It also went further to detail different layers of IoT architecture which are used to achieve different agricultural outcomes. This article covered the technology proposed by the Author to achieve self-registration schemes for IoT devices used in rural areas and areas where internet connectivity is limited. This self-registration proposal is therefore necessary because the reduction of the need for human intervention in the creation of seamless connectivity, the registration process and maintenance of IoT devices in agricultural areas is made simpler. The proper management of IoT devices will create complete and accurate data, supporting the quality of precision agriculture. Self-registration schemes can assist users in the context of decreasing user complexity and enabling ease of setup and maintenance. This strategy is particularly useful especially regarding the technology acceptance factor surrounding subsistence farmers in rural KZN.

Internet of things (IoT) refers to the use of interconnected devices, embedded sensors, digital machines, objects, people, and systems to gather data over a telecommunication network with no human interaction (Burhan et al., 2018; Kurmar and Mallick, 2018). The IoT has the purpose of providing an ICT-infrastructure facilitating the exchange of ‘things’ in a secure and reliable manner, i.e., its function is to overcome the gap between objects in the physical world and their representation in information systems. (Weber, 2010).

Literature revealed that environmental pressures contribute to the threat and existence of global warming, and this can have catastrophic impact agriculture due to the severe weather conditions. It was further highlighted that water supply will be unable to fulfil the world's water needs by 2030, while growing energy demand, labour, and nutrient expenses are already putting pressure on agricultural profit margins. (*UN Press*, 2016)

Proposition 1: adoption of digital technologies can transform subsistence farming in the rural communities.

2.5 Digital technology in rural South Africa

Chogana et el, 2021 used the PEST analysis which a framework that analysed the macro environmental factors to understand how the Political, Economic, Social and Technological factors would affect the outcome of this topic. The PEST is a solid strategy analysis specifically when it pertains to topics that affect an industry as large as the agricultural sector. However, the PEST framework has limitations in that it does not include the Environmental and Legal aspects of this industry which are crucial in determining the readiness of the South African Agricultural Sector to implement IoT. The researcher should have used the PESTEL analysis framework instead, which included all the external macro environmental factors Political Economical Social Technological Environmental and Legal. (*LibGuides*, 2023) The “readiness” of this topic is highly dependent on the Environmental and Legal factors, which have an enormous potential in determining the success and implementation of IoT. In this instance, the environmental factors are the huge contributing factors due to the current climate change, issue, i.e., flooding, droughts, elevated temperature conditions that have the potential to cause natural disasters, as well as other factors that are likely to affect the soil, decreased in livestock production and destroy vegetation. (Zwane,

2019). Legal factors about the implementing IoT are a deciding factor especially in rural settings, where the deciding factors are an agreement by the traditional leaders of the rural area and the party involved in making government decisions. It is a factor that cannot be ignored in the “readiness” The Legal aspects pertaining to the protection and integrity of Data need to be discussed, where and how the data will be stored and the availability thereof. Overall, the writer gave an in-depth PEST analysis that detailed and covered most external environmental factors involved. This demonstrated his ability to understand deciding factors in the internal and external environment to achieve optimum success in his research strategy.

Maluleke (2022) argues that there is a pervasive issue with stock theft on farms, which frequently results in significant losses for farmers' livelihoods and personal finances. Farms are an attractive target for thieves, vandals, and other criminals due to the isolation of many rural areas, the ease with which most properties can be accessed thanks to improved road systems and modern vehicles, the increasing value of the chemicals, machinery, and equipment used on farms, and the portability of the livestock and equipment. Memon, Kumar, Memon, Chowdhry, Aamir and Kumar (2016:1) By using IoT-derived agriculture sensors to affix to the farm animals and track their performance and health, the IoT may be effectively used for managing and monitoring livestock. The tracking and observation of livestock aid in determining the physical location, health, and well-being of the animals. For instance, these sensors can detect unwell animals, allowing farmers to remove them from the herd and prevent contamination. (Chalimov, 2022). The study concluded that although the use of IoT and DNA technology for combating stock theft seemed to be a new concept to the livestock farmers, improvement had been made regarding the current stock theft combating strategies in reference to the application of IoT and DNA technology. It also showed that the farmers and local community members were not knowledgeable about IoT and how it could assist with combating livestock theft.

Technology literacy was recommended to be part of future digital based intervention to create awareness and facilitate adoption of the solutions. The limitation in this regard is that there is no specification on the type of digital interventions referred to and thorough through programme detailing how interventions could have been implemented therefore this could not have worked. Detailing these interventions could have assisted the research findings by using bottom-up approach in understanding digital inventions tools or methods preferred by community of KZN. Data could have been beneficial in further technology acceptance projects.

Dlodlo and Kalezhi (2015) investigated the potential contributions of Internet of Things (IoT) technologies towards poverty reduction in Zambia's and South Africa's rural areas, in line with the needs identified in these communities and with emphasis on agriculture. This study was able to identify a variety of prospective digital applications that could support sustainable agriculture for rural development. Furthermore, it emphasised the potential financial gains that digital technologies could bring to several aspects of agriculture, including water management, weather forecasting, wildlife management, finance, forestry, management of plant and animal diseases, transportation and storage of agricultural products, and extension services. The introduction of livestock or crop smart health cards that save information on impacted livestock or crops may be advantageous to both the veterinarian or agricultural officer and the farmer. Since the officer has access to all previous information regarding the ill animals or crops, this could lead to a quick and accurate diagnosis and prescription. (Dlodlo and Kalezhi, 2015)

2.6 Adoption of digital technologies in agriculture

The adoption of digital technologies in agriculture over the last few years has increased due to the demand for more sustainable agricultural farming and growing social and environmental pressures. These pressures call for more ethical and sustainable farming practices with lower chemical and water uses. Food demand is increasing while the supply side is constrained by land and farming inputs. By 2050, the world's population is expected to reach 9.7 billion people, therefore demanding a 70% rise in the number of calories that are accessible for consumption, even as the price of the ingredients used to produce those calories is accumulating. (World Resources Report, n.d.)

Rallabandi et al. (2022) demonstrated an understanding into the enormity of the task involved into farmers adopting the concept of IoT and the processes and systems involved in the implementation of IoT in agriculture. Researcher agrees with his clear definition of the purpose of enabling Smart Agricultural research is “a farm management decision making system.” This definition simplifies the value that digital technologies add to farming in general, as it details diverse options available to achieve ideal management solutions. This article further dives into other software solutions i.e. eternal software companies that could assist farmers in achieving data driven results by diversifying and using external sources to assist them in the transition and smooth adoption of IoT particularly regarding the education and operational part of IoT. The idea of the diversification endeavour also advocates for job creations, more distribution channels, data resolutions and data ethics and regulations which in turn create opportunities for growth and success. Another principal contributing factor that this article touches on is the lack of finance available to support this initiative. However, it does not expand on how this risk can be mitigated. This factor is crucial in the success of this research and any initiatives by government or organisation willing to fund this initiative.

Matekaire (2001) investigated how digital technology could be used in improving the overall performance of smart irrigation systems and reduce the cost of crop production. The Author gathered insights from a panel of experts using Delphi survey technic and adopted IoT Architectural Framework to assist in conceptualising how various components of an IoT based smart farming irrigation system could integrate with the traditional irrigation methods. The study concluded that traditional irrigation systems have become less effective and recommended that digital technology (IoT) could be leveraged to monitor environmental sensors that detect soil moisture content, humidity, temperature, and irrigation infrastructure. (Pernapati, 2018). The study alluded that IoT based irrigation systems had the potential to significantly improve utilisation of scarce water resources subsequently resulting in the reduction of irrigation operational costs namely the cost of energy to run motor pumps and labour attributable towards the operation of irrigation infrastructure. This study revealed that lack of standards and well-established best practices in smart farming negatively impacts on the potential use of IoT as there are no guidelines to be followed. The study was conducted where smart farming technology had already been implemented and the focus was to integrate IoT in improving the existing smart irrigation infrastructure hence it did not elaborate on the challenges the farmers had encountered during the implementation process. The Technology Acceptance Model (TAM) was adopted for this study. TAM is an information technology framework that models how users embrace and use a new innovative technology. TAM suggests that perceived usefulness, technological ease of use and peer pressure significantly determine the rate of adoption of rate of adoption of modern technology (Alomary & Woollard, 2015). The limitation of TAM is that it focuses on the acceptance of technology and does not examine the use thereof. Additionally, TAM does not focus on the effects of environment (context) and socio-economic factors on technology acceptance. According to UTAUT, behavioural intention defines how technology is used. The direct impact of four

main constructs, including expectation of performance, expectation of effort, social influence, and facilitating factors, determines the anticipated likelihood of adopting the technology. Age, gender, experience, and voluntariness of use moderate the impact of factors (Venkatesh et al., 2003). Understanding these four key constructs will be significant in solutioning and defining how digital technologies can enable farming in rural KZN.

Failure or delay to innovation leads to a dying industry. (Innovate or Die * Drucker Institute, 2010). In the case of farming innovation particularly in the African continent this proves a different quote. Many have suggested that digital agricultural technology innovation, dissemination and use are the keys to unlocking Africa's economic potential. (Langat et al., 2013) There are clear similarities in the case of the adoption of digital technologies in farming in rural KZN, the cultural customs and norms that drive decision making in rural African countries. Recent studies have identified slow agricultural technology adoption rates, which exhibit a hinderance in Africa's efforts to reduce food insecurity and to advance its economy in general. With rural KZN being 54% of the whole of KZN making it one of the most rural provinces in South Africa. It has potential to change economy given its strategic advantage of natural resources and land. However, lack of infrastructure, technological investments, qualified engineers and lack adoption of new business models have affected business efficiency, faster economic growth, and further job creation.

Adoption-related obstacles are recognised and categorised into operational, financial, behavioural, social, and technical domains. While traditional farming methods have their benefits, most of them are losing their effectiveness due to population growth, climate change, and rising food prices. Since agriculture is the main industry in rural regions, the intervention of autonomous systems in any sector may replace the requirement for labour, which in turn creates fear of unemployment. South African subsistence farmers have challenges with

economies of scale because of lack of access to capital, minimal access to farming land and lack of technical knowledge and resources. (Malan, 2018)

Proposition 2: Macro and micro environmental factors have direct impact on adoption of digital technologies in the rural farming communities.

2.7 TAM Technology Acceptance Model

TAM is the chosen theoretical framework for this research. It is a theoretical model that was developed by Fred Davis in 1986. This framework is widely used in studying user acceptance and adoption of technology using two factors, perceived usefulness (PU) and perceived ease of use (PEOU). PU focuses on the extent to which the user believes that using technology will potentially improve their performance or quality of work whereas PEOU focuses on the degree that the user believes that the use of technology will be effortless and easy. The theory states that PU and PEOU have an impact on a user's attitude toward using technology, which then has an impact on their behavioural intention to use it and, ultimately, their actual use of.

Popularised by Venkatesh and Davis (2000), the TAM model has been studied and expanded upon, adding social influences (subjective norms, voluntariness, image) and cognitive instrumental processes (job relevance, output quality, demonstrability of results, and perceived ease of use) to the mix. Venkatesh et al.'s Unified Theory of Acceptance and Use of Technology (UTAUT) (2003) is one of the other adaptations. The impacts of perceived risk and trust on the use of IT or technology systems are new factors added to the TAM 3 model in the context of e-commerce (Venkatesh & Bala, 2008).

TAM suggests that perceived usefulness, technological ease of use significantly determine the rate of adoption of rate of modern technology (Alomary and

Woollard, 2015). This framework was selected for this study because the study focuses on introducing new technologies into subsistence farming process. It deals with farming communities which are traditional and potentially have low digital literacy. Technology adoption is heavily influenced by how users perceive the value of technology in improving their lives, but sustained impact and embedment are influenced by perceived ease of use. Full digitilisation would require acceptance, incorporation, and use of the technology into the current traditional practices. For people involved in the agricultural industry, the Technology Acceptance Model (TAM) makes sense since it explains how technology is adopted based on its perceived utility and simplicity of use. This model also allows gradual step by step approach in making sure that every step is achieved to move to the next step. This is particularly beneficial in rural communities especially in breaking traditional habits and norms and creating an understanding and familiarity of technologies amongst the farming community and allowing assessment of attitude, behavioural intention to use and actual system use. If this model is effectively utilised, it can transition smoothly to acceptance and use.

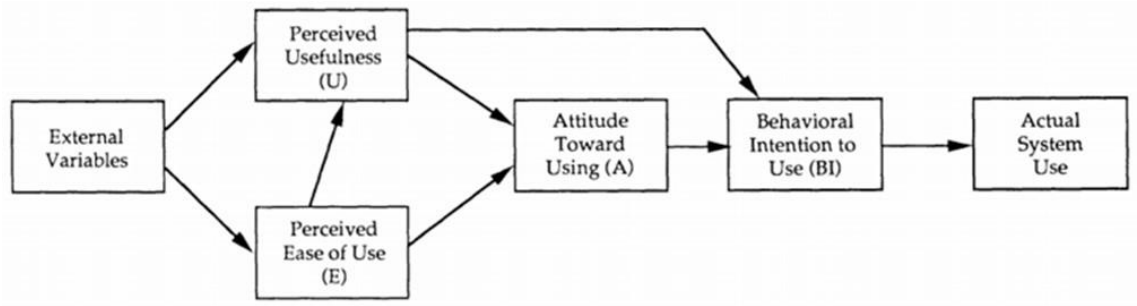

Figure 2-2 *TAM Framework (Enablers of Change*, 2023)

2.7.1 *Conceptual Framework*

This conceptual framework is key in building awareness around digital technologies and facilitating understanding of the technologies and the value they can add to the current traditional farming practices in rural KZN. Stakeholders such as farmers, local authorities can utilise this conceptual framework which integrates various enabling components of digital agriculture illustrated in Fig 2-2. By adopting this framework, farmers can leverage digital technologies to improve their crop and livestock yields, optimise resources usage and enhance overall agricultural productivity.

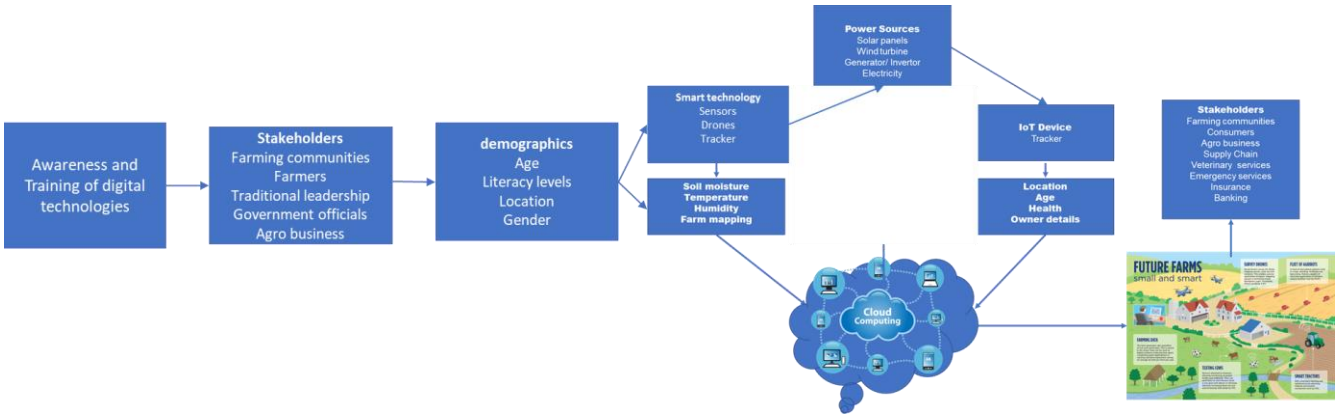

Figure 2-3 Conceptual Framework by author adapted from TAM

This framework will consist of the following integrated and enabling components.

Training and support: Training builds awareness and creates understanding and these are key in contextualising perceived value and ease of use of digital technology. Prioritising farmer training and support ensures that they are enabled effectively utilise digitalised farming machinery and gargets. Training can also be extended to enabling stakeholders such as local government, traditional leaders, financing institutions, ICT companies, and research and academic institutions.

Training can cover the value of digital technologies in farming, data interpretation techniques and implementation of these into actionable solutions.

Stakeholder engagements: Engaging the stakeholders to understand training needs and the current challenges impacting on the farming industry in the communities, the roles that the specific stakeholders' groups need to play in enabling the integrated digital farming model.

Demographics: Factors such as age, gender, location, and literacy levels have been proven to influence the rate of digital adoption according to social trends. These factors will be considered when designing targeted digital interventions to ensure that they are affordable and easy to use. This can increase the rate and ease of digital adoption in the farming communities.

Sensor allocation: Placing sensors in the farms to gather information on the soil moisture, humidity, and arm mapping. These sensors can be positioned in or at weather stations, on plants, or in the soil.

Data collection and connectivity: Creating a network infrastructure allows efficient data collection from deployed sensors.

Cloud platform and data storage: The secure and scalable storing of acquired data on a cloud-based platform. This makes data management effective, globally accessible as well as gives the industry a competitive edge.

Data analytics and insights: Using data analytics techniques to extract valuable insights from the collected data. Making educated farming decisions using machine learning algorithms to predict crop and livestock health, identify illnesses, and optimise irrigation and grazing schedules.

Mobile and web applications: Creating user-friendly mobile applications that give users instant access to the data and insights gathered. With the help of these

applications, farmers can monitor their crops or livestock, get alerts, and communicate with the system to make better decisions.

Knowledge sharing: Promoting the culture of knowledge sharing among farmers by including information on lessons learned and best practices in the framework. This can consist of providing educational resources and localised farming forecasts for efficient future planning.

Integration with the existing systems: Integrating the digital technologies framework with existing agricultural systems and practises to ensure compatibility and seamless adoption. This may involve collaboration with institutions such as the department of Agriculture and Forestry and Agribusiness Development Agency (ADA) (Bolfe et al., 2020)

HUBVELA (2023) stated that adoption of digital technology has significantly transformed the global farming industry however, as with any innovation, there are both gains and drawbacks that come with it. Some of these have been summarised in the table below:

Advantages of enabling digital agriculture technologies	**Disadvantages of enabling digital agriculture technologies**
Reliability, efficiency, and accessibility	Cost of implementation and maintenance of IoT devices i.e., insurance
Ease of access to data	Natural disasters

Interconnectivity of services and applications	Reliability of power supply
Enhanced data collection and decision making	High dependency on power supply and internet connectivity
Minimised human effort	Availability and reliability of network connectivity
Widened geographical trade opportunities	Low levels of digital literacy

2.8 Conclusion of Literature Review

Upon analysing all the literature, most observations were made on articles on "general farmers and agriculture and the role digital technologies play." articles on enabling digital technologies in rural subsistence farming are limited. Having researched and understood the general meaning of subsistence farming, it is apparent that most researchers still understood the word subsistence in the primitive way of small farms and low yields, without the knowledge of social and business trends that have improved methods currently used. These farmers have a wealth of transferable knowledge since most of their skills have been passed down from generations. Subsistence farming is a growing industry that deserves invested attention.

Reflecting on the articles, across all agricultural farming methods, digital technologies have played an innovative role into modern and smart farming. The

concept of digital agriculture technologies in improving farming methods using tools such as drones to monitor crops and trackers to monitor livestock is transforming subsistence farming activities. Literature also highlighted that although subsistence farmers possess knowledge in farming methods, further digital and technical education and training are required to ensure sustainable financial and trade improvements. It is also important for them to understand the importance of conserving their environment. The role of government and corporate organisations is crucial, in participating in funding and improvement of smart agricultural equipment and internet connectivity to maximise economic growth. In Fig 2-2 and Fig 2-3 of the Theoretical framework that details the process of technology acceptance and use, as well as the Conceptual framework that details the suitable process implementing plan for digital technologies in rural KZN and the advantages and disadvantages thereof. To this study the conceptual framework is utilised, which contributes to the research's qualitative studies.

Farmers may be able to produce a surplus if they are encouraged to seek smart farming through the application of improved inputs, which will boost the sustainability of farms. Governmental policies and initiatives need to be reviewed and reinforced to enable crop and livestock data to be regularly updated to meet legislative requirements. Projects for local development could offer training to support the skill and knowledge development of rural subsistence farmers so they can produce a higher output. Government participation and funding is the key to acceleration of digital technologies in subsistence farmers. Due to KZNs geographic conditions and vast lands, farming is an important economic sector that is likely to keep growing. This growth has increased service-oriented business models that serve the consumer in this era of digitalisation by using cloud computing and IoT. This Cloud can serve as a hub for local businesses such as banks, insurance, agro-businesses, and veterinarian professionals to be able to access data for research and development, data on health history, ownership documents, birth records, age, and location. Enabling digital

technologies will not only assist subsistence farmers gain their livelihood, but it will also enhance productivity and allow expansion into new markets as well resulting in job creation and general economic growth in the region.

CHAPTER 3. RESEARCH METHODOLOGY

This chapter comprises of the research methodology used, which include, the research approach, research design, data collection methods, population and sample, the research instrument, procedure for data collection, data analysis strategies and interpretations, possible limitations of the study, quality assurance, ethical consideration and proposed schedule and timeline.

3.1 Research approach

A qualitative approach was adopted to answer the research questions. Through qualitative research, a researcher can build a theory or look for a pattern in the data they have collected. Systematic methods are used to collect data, but this does not imply that the data is statistical in any way. Authentic information is acquired from participant interactions and observation using the individuals' interviews and case study techniques: (Tenny et al., 2022).

Qualitative approach looks at studying and offering more profound understandings of real-world issues. Using Qualitative research aids in the generation of hypothesis, as opposed to gathering numerical data points or intervening or introducing treatments as in quantitative research. Qualitative research collects the views, behaviours, and experiences of people. Rather than addressing how many or how much, it addresses how and why. (Moser & Korstjens, 2017)

Subsistence farming is a way of life in rural KZN and understanding the participants livelihood, and their perceptions on the value of digital technologies was critical in answering the research questions. This approach was suited for this research as gathering information in rural areas from participants that may or may not understand digital technology and its benefits may require prompting,

observing behaviour, providing detailed explanations using visuals and gathering views.

3.2 Research Paradigm

The research paradigm is the framework within which researcher's discipline's ideas and practices are integrated to form the research plan. This foundation drives all aspects of the research strategy, including the study's purpose, research question, instruments or measurements utilised, and analysis procedures. Interpretivists paradigm was used in this research. (Ulz, 2023) This framework was suitable because the study focused on a social context, livelihood of rural farmers and their perceptions towards the digital technology. The findings of the study would be subjective to the participants views and experiences and these would only be valid based on the context of this study.

3.3 Research design

Research design refers to the overall approach the researcher selects to integrate the various study components in a coherent and logical way, ensuring that they successfully address the research problem. It serves as the guide for the data collection, measurement, and analysis processes. The sort of design utilised is determined by the study challenge (Sacred Heart University Library, 2020). For this research, the Generic Qualitative research approach is used. The goal of generic qualitative research is to gather information using language and words and no numbers and measurements. Generic qualitative inquiry is used to investigate people's accounts of their subjective views, attitudes, beliefs, or thoughts on things they have experienced in the outside world. This definition provides guidance on how to apply a general qualitative inquiry in the right situation It is more focused on people's experiences.

3.3.1 *Data collection methods*

Data collection is the methodical process of acquiring facts or statistics. Whether it is conducting research for business, governmental, or academic reasons, data collection enables researcher to gain in person information and unique perspectives into your study challenge. (Bhandari, 2020). Face-to-face interviews were used with the farmers. This type of collection was particularly beneficial in gaining as much in-depth knowledge as possible especially since the possibility of technology infrastructure challenges as well as education barriers were perceived to be potential challenges.

3.3.2 *Population*

There are around 400.000 rural agricultural land user households in rural KwaZulu Natal. (Ngema et al., 2018) Zululand district municipality was selected as the areas of study. Zululand has population of 942794 people. (Zululand District Municipality - Demographic, n.d.) Population of this study consisted of subsistence farmers and stakeholders aged 18 and above, gender male and female. All the participants were South African nationals and residents living in rural KwaZulu Natal municipalities like Zululand, Ugu, Uthugela and Mkhanyakude.

3.3.3 *Sample and sampling method*

Convenience sampling method was adopted for this study. This is an effective method for figuring out the sample size is required to accurately represent a given population due to the continuously growing demand for research (Krejcie & Morgan, 1970). Specific municipal area in KwaZulu Natal with a larger number of subsistence farmers be chosen to achieve a reasonable number of responses. Ten to Fifteen participants were targeted for the study and Zululand municipality

was chosen for the most sampling. When conducting an in-depth qualitative study and considering population of Zululand at 942794 and subsistence farmers at 757000, the sample size of ten to fifteen was considered appropriate because large volumes of data are deemed inappropriate and inhibit meaningful and timely qualitative analysis. This could cause data saturation would require justification and deemed unappealing (Guest et al., 2006)

3.4 The Research Instrument

The research instrument used for this study was an interview guide. The questions were designed with an aim of seeking insights and addressing the main research questions. The questionnaire consisted of thirteen questions, four of sought to understand the participants demographic profiling such as age, sex, and educational achievement. The other nine questions were open-ended and focused on the participant's farming experience, their exposure and perceptions around the use digital agriculture technologies and perceived enablers and barriers to digital adoption. The questions were designed to further prop the participant to provide more precise responses where the researcher felt it was required. The researcher scheduled face to face physical interviews where they facilitated, read out and explain the research questions where necessary to ensure that the participant understood the questions, and that the correct information was provided.

3.5 Procedure for data collection

There were various data collection methods that were used in this study. The researcher used face-to-face internet-based or physical (in person) interviews. It is important to note that though the research instrument was written in English, most of the interviews we conducted using isiZulu language. This was because

some of the participant did not speak or have a clear understanding of English. The researcher had to explain the questions in isiZulu and scribe post the interviews. Prior appointments were scheduled and information regarding the study including the research instrument were shared to allow the participants enough time to discuss any other issues they had especially regarding digital technologies. The assumption was that this would be where the most time would be spend clarifying the subject matter. The participants chose a time slot convenient to them and an initial length time of 60mins was allocated. A consent form was provided for the participant to sign. Audio recordings were conducted for some interviews however there were participants who indicated that they were not comfortable with the audio recordings, and this was indicated on the consent forms. In other instances, audio recordings could not be conducted because of recording devices not having power, and network interruptions due to loadshedding. The recordings will be referenced when completing the data analysis and appropriate processes to keep and discard the data will be employed according to university guidelines.

3.6 Data analysis strategies and interpretation

This research undertook a thematic study which is the process of using qualitative data analysis to form themes and patterns using research questions (Braune & Clarke, 2006).

- The interviews were audio recorded and later transcribed into text reports.

The interviews conducted in isiZulu, transcribed verbatim and translated into text in English. In order to ensure the reliability of qualitative research, translation is a crucial step in effectively communicating participants' meanings across linguistic boundaries (Yunus et al., 2022).

- The participants responses were analysed and classified into themes and sub themes.
- Some of the themes and sub themes were renamed to align to the research questions and the propositions made in the study.
- Other themes which emerged and were irrelevant to the study were not included in the study.
- The identified themes and sub-themes were analysed in detail in chapter four.

3.7 Quality Assurance

3.7.1 *Transferability*

The ability to generalize a study's results to different circumstances, persons, places, and measurements is known as external validity. The goal of the study was to generate knowledge that could be applied to the real world. Researchers could not extrapolate results to other people or the actual world if the external validity is low. Research biases, including under-coverage bias, will affect these findings. External validity consists of population and ecological validity. Population refers to whether you can broaden research to include contexts outside of only the study setting. Whilst Ecological validity is the ability to appropriately apply the results of a research study to additional contexts and settings in the "real world." (Bhandari, 2020). The participants were South African nationals and residents, the researcher ensured that internal validity was not jeopardised, and that the data collection procedure was uniform throughout the study. Consistency in the data-gathering process was ensured using an interview guide.

3.7.2 *Credibility*

Credibility is the initial aspect required to be established. Trustworthiness is regarded as the most crucial factor in determining trustworthiness. This is owed to the fact that establishing credibility requires the researcher to show a direct connection between the research study's conclusions and reality. In comparison to the other components of trustworthiness, credibility also has the most methods for establishing it. Since triangulation and member checking are the two approaches used the most frequently in qualitative research, concentration on them in this study is required (Moran, 2017). The appointed research supervisor had to review, and report compared to the raw data collected to ascertain that it was credible.

3.7.3 *Dependability*

The raw data, like research instruments, audio recordings and Microsoft Teams recording have been kept as proof and to also be revisited should there be a requirement to validate data. External auditor, who in this case could be a researcher who was not involved in data collection and analysis, looked through those methods and researched study's findings. This was done to ensure that the findings were accurate, and that the data obtained supported the conclusions. The validity of all decisions and interpretations was assessed against the data itself. Inquiry audits are advantageous because they allow a third-party researcher to investigate, consider, and question the methods used for data analysis and interpretation (Moran, 2017).

3.8 Ethical considerations

The University's ethical approval procedure was adhered to when conduct all primary research. Participants were given the freedom to leave the study at any

point during the research process when they felt uncomfortable. All participants will remain anonymous. In instances where audio recordings were part of the interviews, participants were informed prior to the interview that recording will be in process during interview for them to prepare and take into consideration whether to participate in the interview or not. The objective to complete and sign consent form was explained. Participants were also informed that their identities will remain strictly confidential, and no form of identification will be required. Transcripts were altered to remove any references, including names of people and businesses, which were included in the primary research. Interview transcripts, scribes and audio recordings will be safely maintained on the university's OneDrive before being permanently erased.

CHAPTER 4. PRESENTATION OF FINDINGS

4.1 Introduction

This chapter presents key finding from the interviews with subsistence farmers and their family members in rural KwaZulu Natal's municipalities. The total participants of 11 individual face to face interviews and 2 focus groups that consisted of 5 individuals each. The interviews were all allocated 1 hour per participant although the older participants took a lot longer because of detailing of visuals and explanations of the technology that could be made available. The participants responses were analysed using deductive thematic analysis.

The research instrument was developed to address the research questions which were:

- What is the perceived value of the use of digital technologies, in rural KZN?
- What benefits will digital technologies have on the community of rural KZN, and how will it contribute to improving agricultural practices and outcomes?
- What are the perceived challenges of implementing digital technologies farming solutions in the of rural community KZN?

4.2 Personal demographics

Table 4.1 Demographic profiles of the interviewed participants

Participants	Village/ Municipality	District Municipality	Gender	Age Group	Level of education	type of farming practiced	Duration in farming
Participant 1	Ulundi	Zululand	Male	46 years to 55 years	Postgraduate	Livestock- cattle, goats, and sheep	10 years
Participant 2	eNkonjeni	Zululand	Male	36 years to 45 years	Grade 12 and below	Mixed Livestock - Cattle, Chickens Crop - Mealies, Potatoes, fruits	30 years
Participant 3	Port Shepstone	Ugu	Male	56 years and above	Postgraduate	Livestock - Goats, cattle, and sheep.	60 years
Participant 4	Bergville	Uthugela	Female	36 years to 45 years	Postgraduate	Mixed Livestock - chickens Crop - vegetables.	5 Year
Participant 5	Nhlungwane	Zululand	Male	46 years to 55 years	Postgraduate	Livestock - cattle and goats	10 years
Participant 6			Male	36 years to 45 years	Degree level	Mixed Crops - (vegetables), Livestock - indigenous chickens and goats	10 years
Participant 7	Mkhuze	Umkhanyakude	Male	37 years to 45 years	Degree level	Mixed farming. Livestock - cattle, sheep, and goats. Crop - cabbage, mealies, and spinach	20 years
Participant 8	Endlebe	Zululand	Male	36 years to 45 years	Postgraduate	Mixed	35 years
Participant 9	Ulundi	Zululand	Male	56 years and above	Grade 12 and below	Livestock - cattle and goats.	60 years
Participant 10	Nkonyeni	Zululand	Male	36 years to 45 years	Grade 12 and below	Mixed Livestock - cattle, sheep, and goats Crop – Potatoes, mealies	1 year

Participant 11	eNkonjeni	Zululand	Male	56 years and above	Grade 12 and below	Crop – mealies, potatoes	20 years
Participant 12	Kwatontiyane Ezibomvu Othine Kwavuzunya wo Kwaphindang ene Kwanqwanqw asi	Zululand	Male	15 years to 25 years	Grade 12 and below	Mixed - cattle, goats, sheep, and indigenous chickens	20 years
Group 13	Kwatontiyane Ezibomvu Othine Kwavuzunya wo Kwaphindang ene Kwanqwanqw asi	Zululand	Male	16 years to 25 years	Grade 12 and below	Mixed Livestock - cattle, goats, sheep, and indigenous chickens. Crop - Potatoes, mealies, cabbage, and sweet potatoes.	20 years

Age

Participants who were interviewed were aged between 20 years and 80 years and the majority were between 36 years and 45 years. More solid responses were received from the age group of 45 years and older, because they had a more personal and business-related knowledge in farming methods as well as past challenges and future endeavours that could attempt to assist in digitalising and sustainability. The 45 years and over age group also had a willingness to participate and honour the appointments because they had a much more personal reasons as well as a passion for farming and finding solutions to their current social, political, economic, and environmental issues. All the 45 years and more were owners of the farms that were all passed on through generations. Farming has been practised and taught from childhood and that was the main skill they had all acquired and has afforded them they life they currently have, farming to them is the only option.

The age group that was 35 years and younger were willing participants, but they needed constant reminders and reschedules of interview meetings. Most had a busy lifestyle that involved farming but they had also decided to embark on other career prospects. This age group had a positive attitude towards the interview and answered all questions with enthusiasm and clarity. Although they amended meeting times, they were able to communicate very well and were sensitive to time wasting and making sure that they arrived in time and answered all questions to the best of their knowledge. Altogether everyone was pleasant and contributed positively to the research questions asked, their attitude was testament to their work ethic as well as their positive contribution to the future of farming in KZN and South Africa as a whole.

Literacy

There were six participants with postgraduate qualifications, they were deeply knowledgeable in farming methods particularly modern farming methods. They were very enthusiastic about global warming issues pertaining to lowering the carbon footprint as well as infrastructure upgrade and farmer accountability for preserving the environment. They were also financially savvy and had concerns about the cost of the technology upgrade to the farmers and their questions as to how much the government would fund the upgrade. Major concerns in the actualisation of all the research as many researchers have previously completed surveys and no structural upgrades have been completed. Thorough explanation was given to make sure that participants understood stood that the nature of the research was to gather data and analysis for future projects to be executed using bottom -up estimates. Most participants were familiar with research and understood but were more eager for the technology infrastructure to begin as so many delays are causing slow economic growth in the province. They believe that the acceleration of IoT, Tags, Power cabling, faster broadband speeds and more mobile towers in the rural areas could help grow the agricultural industry

and have a massive impact on the increase of our GDP. This was of outmost importance as most of them owned the farms as an inheritance, only one in the group was directly leasing his own farm. They further showed concern regarding sustainability making sure that all equipment used is environmentally friendly low emissions and cost effective. Current leadership was also discussed in terms of politics and the vision the government had for sustainability. Upon lengthy discussions many were happy with information collected and wanted to emphasise the importance of transparency and ethics especially in data collection.

Two participants had already completed a degree, and in pursuit of honours degree. This group was very responsive, answered questions more clearly and raised a lot of questions. They were particularly intriguing because they had been exposed to farming from an early age because of being born into a farming family that either for their livelihood or farming as a business. Interests were in the technology itself and the amount of value it can add to rural KZN. There was also an issue of stagnation of technology upgrades and the slack on projects started that have not been completed and the lack of projects that have made real impact in the community and the agricultural industry. They also mentioned a few educational initiatives that have since been introduced to educate the community in the use of technology and to assist in technology acceptance. Initiatives were an innovative idea but required consistency and persuasion for maximum attendance. The general feel was that the project was structured as a general project for the country and not location specific and not tailor made for the rural areas. The group emphasised that any initiatives from government need to have a clear vison that aligns with the rural people of KZN and focus on the needs of the community and not government or personal financial gains.

Majority of the participants had matric and lower levels of education; they were male farmers. Farming symbol of status and family legacy which is passed from generations through male children. The only lady had inherited the farm and was well educated. She was able to employ workers whilst she managed the management and administration of the farm. According to Agarwal,1977 the role of a woman in the initiation and planning of development programme is crucial because it is said that women are closer to nature and the environment than men. KZN is the third largest province in South Africa with 53.1% of females. There are more females than males, but more males tend to spearhead the farming in KZN.

Location

Most of the participants where in the Endlebe, Ulundi, eNkonjeni, Nhlungwane and Kwatontiyane, Ezibomvu, Othine, Kwavuzunyawo, Kwaphindangene and Kwanqwanqwasi rural communities from Zululand municipalities. the other participants were from Mkhuze in Mkhanyakude municipality, Bergville in Uthugela municipality and Port Shepstone in Ugu municipality. Zululand municipality was selected based on non-probability sampling method. 30% of the participants worked in Zululand and were available for the study.

Type of farming

Majority of the farmers practised mixed farming which consists of livestock and crop farming. The participants mentioned that their choice of farming was influenced by their knowledge but mostly availability of resources such as land, water, security, and financial resources. Livestock that is farmed the most in these communities are cattle, goats, and sheep. Crop farmers are focused on mealies, potatoes, and cabbage.

Farming duration

All the interviewed participants have historical knowledge of farming because they grew up in families where the practise was a way of sustenance. Two participants who were above the age of 70 mentioned that they had farmed all their lives, and it was through farming that they also provided for their own families. These participants were steadfast on their traditional farming ways and had perception that adopting digital technologies was somehow invasive. The participants from the focus groups are below the age of 25 however they have been exposed to farming all their lives and the parents are trusting them with most of the responsibilities to look after the family farming practices.

4.3 Theme development

Deductive approach was used for coding and theme development. This approach was used as it investigates an established theory or phenomena and determines if it makes sense in the conditions at hand. A deductive research technique investigates an established theory or phenomena and determines if it makes sense in the conditions at hand. It has been observed that "the deductive method most closely adheres to the logic path. A new hypothesis follows from the reasoning that begins with a theory. The purpose of testing this hypothesis is to present it with observations that either support or dispute it. (Deductive Approach (Deductive Reasoning), n.d.)

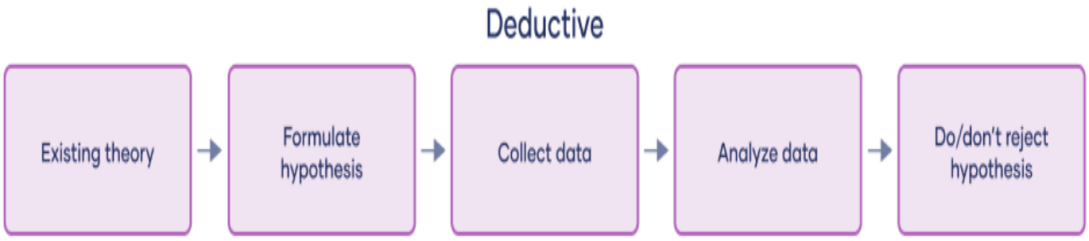

Fig 4-1 Deductive research approach (Streefkerk, 2019)

The findings of the interviews were analysed and grouped into themes and sub themes. these we classified into six themes, namely benefits of subsistence farming, perceptions and awareness of digital technologies, enablers of digital technology adoption, socio – economic challenges and digital adoption, perceived inhibiting factors of digital technologies and proposed infrastructure solutions for full digitilisation. These are presented in the table below with the identified sub-themes. will be analysed in detail in chapter 5.

Theme	**Sub-theme**
Benefits of subsistence farming	• Family sustenance • Trading income • Development of farming skills • Job creation
Perceptions and awareness of digital technologies	• Awareness • Perceptions
Enablers of digital technology adoption	• Reliable power supply • Security • Capital investment. • Digital literacy • Cost of digital technologies • Access to farming land
Socio – economic challenges and digital adoption	• Natural disaster • Livestock theft • Technology and digital awareness • Access to commercial market

	• Physical infrastructure • Capital investments
Perceived inhibiting factors of digital technologies	• Lack of capital investment • Lack of awareness and understanding
Proposed infrastructure solutions for full digitilisation	• Partnerships • Capital investments • Investment in alternative power supply • Digital Literacy campaigns

Benefits of subsistence farming

Family sustenance

All participants indicated that subsistence farming is basic source for their family sustenance, they can provide fresh meat and produce for their families. They indicated that subsistence farming has assisted with poverty alleviation within their homes and their communities as they are able to share their food with the community needy members. Three participants said they were able to pay dowry for their wives. This was not only a form of barter but also secures family title and a form of security for both families demonstrating hard work, dedication, family wealth and an assurance for future generations.

> "*My* family *eats fresh unprocessed food. We eat and drink freshly produced milk and slaughter meat whenever we want. We can make our own sour milk aka amasi I also have cash benefit from selling livestock*

when there is need for money like paying school fees. I have also paid bride price (lobola) for my wife using my livestock." Participant 9

Trading income

Eleven out of thirteen participants said that they make money through selling surplus produce as well as selling livestock in informal market or at auctions when they have financial needs. Most have alluded to funding their children's education through subsistence farming. Slaughtering of livestock such as cattle and goats is part of the traditional rituals in the Zulu culture and these practices are still very prevalent in rural KwaZulu Natal. The traditional rituals of the Zulu culture are an imperative part of their financial growth and general livelihood. Slaughtering for ancestors is also pivotal in acknowledging the past and future of family wealth and land provided by the ancestors in enabling them to achieve their desired outcome. The participants have indicated that they observe high livestock sales when there are traditional ceremonies such as funerals and weddings.

"I save cost on food because we have access to fresh vegetables from the garden. Additionally, when there is a funeral or traditional ceremony at home, I am able slaughter my cows and goats. Sometimes life emergencies happen when one does not have money to cover the cost and, in this instance, having livestock is helpful. We also sell livestock to the communities when there are traditional ceremonies like weddings, ancestral functions, or funerals." (Participant 6)

"We have access to fresh milk from the cows and fresh vegetables from the garden. There are cash benefits because of selling surplus vegetables and occasional livestock sales to local communities" (Participant 8)

Development of farming skills

The young participants, learners have also attributed their interest in farming to the exposure they had at home observing their elders and learning traditional ways of farming.

> *"We have learned a lot about livestock and crop farming from observing our families' farming traditions. We would like to study farming related courses at tertiary so that we grow the family farming practices into commercial practice." (Participant 13)*

> *"Subsistence farming has created an opportunity for me to learn about different types of farming. I have established networks with other small farmers, and I believe these will be essential in my development. I would like to grow my farming practice into being commercial and contribute towards the South African economy." (Participant 4)*

Job creation

One of the participants indicated that subsistence farming contributes to job creation in their communities. They offer employment to the needy community members to herd the livestock and cultivate the fields.

> *"Through subsistence farming, we can reduce the levels of poverty in our community. I provide livelihood for my family from money I make from selling surplus produce. I employ members of the local community at my farming practise to herd the livestock and cultivate the fields. The community members are either renumerated using cash or livestock to sustain themselves and their families." (Participant 7)*

Awareness and perceptions of digital technologies

Awareness

Four of the thirteen participants mentioned that they are aware of other farmers who have adopted digital technologies, these include hydroponics, Global Positioning Systems (GPS) used in mapping farm boundaries, farm designs and irrigation systems, drones used in surveying the farms for security and to also monitor crop and soil health, satellite imagery which assist with weather monitoring. Participants have also witnessed the use of sensor technologies in livestock tracking and health monitoring. The farmers who have adopted these technologies mentioned that technologies have improved their productivity because they are able to make smart decisions informed by insights from data analysis about the weather, soils health, livestock, and crop health. The smart machineries used for ploughing, harvesting and irrigation have increased efficiencies at the farms resulting into less labour-intensive farming practise. The farmers have admitted that the initial capital investment into digital technologies has high and they needed funding and sponsorship to implement the technologies. The participants highlighted that they observed these innovations at commercial farms closer to the cities and none of these where in a remote rural community.

> *"Yes, I know farmers who use tracking devices on their livestock and drones for farm monitoring. They enjoy the benefits of the digital technology because they have improved security, they can monitor predators and intruders from their smartphones. Farmers can combat livestock theft. They are also able to monitor livestock's fertility, general health and mitigate risks such as they are identified." (Participant 1)*

> *"Lilly farmers use hydroponics to control the temperature for effective growth. Some chicken farmers also use digital air conditioners and heating lights to keep the chickens warm. The farmers have expressed*

> *that although the initial investment is high, adopting digital technologies make farming easier." (Participant 4)*

The remaining nine participants mentioned that they do not know of farmers who have adopted digital technologies.

Perceptions

Eight of the thirteen participants indicated that they have considered using digital technologies however only three have mentioned that they have used them. There is a general perception amongst participants that the cost of using and maintaining digital technologies is high and subsistence farmers believe that they will need government to subsidise and sponsor digital adoption in rural KwaZulu Natal for them to participate in the digital transformation. Technologies which participants considered included, CCTV cameras for monitoring, sensor for livestock tracking, hydroponics and digitised water pump.

> *"I am using heating lights for the chickens. I would like to also use hydroponics for the vegetables however the initial investment is high, and it is also labour intensive. The other digital technology I would like to implement is water pump for irrigation because this will increase the efficiency on the farm." (Participant 4)*

The other five participants said they did not know about digital transformation before the interviews, and some indicated that they would like to learn more as the believe that they can assist them with improving their farming.

> *"No, had not considered using these tools before the interview as I had no knowledge that they exist. I would like to know more about sensors for livestock monitoring. I believe that it would safe us the time of herding cattle and we could use the time more efficiently like focus on improving crop farming." Participant 10*

Enablers of digital technology adoption

Enablers are the factors which are required to ensure that digital technologies are implemented and adopted successfully to facilitate digital transformation. Several enablers were identified during the interviews and findings are discussed in detail next.

Reliable power supply

Seven out of thirteen participants stated that reliable power supplies are their critical enabler in adopting digital technologies.

> *"I would need electricity or reliable source of power. There is fundamental problem of power shortage in our area. We spend days without power, and this would be inconvenient as I would not be able to use digital technologies efficiently." (Participant 1)*

> *"I would need reliable power source; network connectivity and money invest for me to start using digital technologies". (Participant 12)*

Physical Security

Five of the thirteen participants mentioned that they will need security to adopt digital technologies as they would need to safeguard the tools. Theft has been highlighted as one of the main challenges that farmers deal with in the rural KZN areas. The researcher made observations during the interviews that most of the participant's homesteads are fenced around with simple bob wire instead of strong fence to prevent forceful and malicious entry from intruders. The participants also mentioned that there have been instances where the employees have been part of the criminal syndicates who vandalised and stole from their properties.

> *"I would need security to prevent theft of the technology I would have implemented. The level of crime is high in this community. I believe that implementation of digital technologies such as monitoring cameras, smart irrigations systems and sensors would attract criminal to my farming practise. I would need to hire security to safeguard the technologies, and this contributes to the cost of the digital technologies." (Participant 2)*

Capital Investment

Eight of the thirteen participants mentioned that capital investment as an enabler, indicating that they believe that digital technologies are expensive to purchase, and they would need to maintain them which is an additional cost.

> *"I would need capital. I believe that the cost of installation and maintenance is high.*
> *We have poor to no network connectivity most of the time and digital technologies require internet connectivity. The farm is in fields where there is no power and this would make it impractical to adopt digital technologies. There is water scarcity around the farm, use water tanks to collect water for irrigation and for the livestock." (Participant 3)*

> *"Capital investment. The cost of implementing and maintaining the technology tools is high and I don't have the sponsor to fund installing digital technologies." (Participant 4)*

Awareness and cost of digital literacy

Five of the thirteen participants indicated that they need digital literacy to adopt digital technologies. The participants are not aware of these technologies, and they also do not know how they work. They have said that they would need to be

trained on what the tools are and how they can utilise them to improve their farming practices.

> *"Imparting the knowledge and skills to operate the technology is beneficial to enable adoption. There should be a drive here in the rural areas to educate small farmers and learners about digital technologies and how these can improve rural farming." (Participant 6)*

> *"I need capital investment and technical skills. I have minimal knowledge of technology, but I would not be comfortable with using sophisticated tools. I together with farm employees will need to undergo training." (Participants 7)*

Socio – economic challenges and digital adoption

Livestock theft

Nine of the thirteen participants mentioned that there is remarkably high rate of livestock theft in their communities. The farmers use ear tags and the personalised marking engraved on the livestock for identification however these have not assisted in curbing the theft. The researcher saw when conducting interviews in the villages that livestock was left to roam freely in the fields without human supervision. When probing why this was the case, five participants indicated that they use ancient traditions to protect their livestock from theft.

"There is high rate of livestock theft in this area. Our cattle and goats are left to graze in the open fields without human supervision. This is where thieves take advantage and steal livestock. We ensure that they return home by performing a traditional ritual where we burn medicinal herbs and call them back home. This tradition has been practiced through

> *generations and has proven to work as the animals do return home." (Participant 9)*

> *"Livestock and crop theft - people who look after livestock or crops are often part of the syndicates stealing from the farmers." (Participant 3)*

Some participants mentioned that adopting digital technologies such as sensors to monitor livestock can assist with decreasing theft as well as monitor livestock health.

> *"I believe that if livestock could have trackers to enable monitoring and movement, the care takers could be alerted when the livestock is moving into danger zones. This could also assist with livestock theft." (Participant 7)*

> *"Subsistence farmers have limited to no access to farming land. We have a big challenge with high livestock theft and disease outbreaks. Adoption of modern digital technologies can assist farmers to monitor their livestock. They can easily identify sickly livestock as soon as diagnosed. There can be communication groups where information can be share speedily and specialist can also form part of the social media groups such as WhatsApp and Facebook" (Participant 1)*

Natural disasters

Most participants indicated that their farming practices have been negatively impacted by the floods and heatwaves which have been prevalent in KwaZulu Natal in the recent years, and this threatens their food security. Some crop farmers have indicated that they have noticed pests and crop diseases which were not prevalent years back and they are unable to diagnose and alleviate as

they do not know what they are they also cannot afford professional agriculture advisory. Three participants mentioned that they have a problem of monkeys and birds invading their farms and gardens to eat and destroy their produce. Due to low levels of digital literacy in this communities, some participants did not know which technologies could be used to resolve their challenges however they were open to learning about digital solutions which could assist them.

> *"Plague of worms and pests infesting the crops in the fields affects the hare, we have experienced significant loss of yield due to diseases causing poverty in the family and community. I do not know how technology can assist us with solving this problem, but I am open to trying it out." (Participant 10)*

> *"The farmers in my community have a challenge of birds and monkeys eating and destroying crops such as mealies, tomatoes. There is also a challenge of weeds which make it impossible for the crops to grow resulting in lower harvest.*
> *I do not know how technology can assist but we would appreciate the assistance in dealing with these challenges." (Participant 11)*

Access to commercial market

Some participant indicated that they have challenges with accessing markets to sell their produce and livestock. Economies of scale drive the profits in agriculture and by nature, subsistence farmers only sell surplus from their produce which significantly minor compared to commercial farmers whose main object of farming is commercial. Farmers markets are usually close to or in the cities which further disadvantages subsistence farmers who cannot move their livestock or produce as speedily as their competition due to factors such as poor road infrastructure, lack of suitable transportation.

> *"Farmers market conditions are not favourable to small farmers. One needs volumes to make good money and subsistence farmers only take surplus to the market." (Participant 1)*

> *"A small percentage of small farmers sell their produce to local shops and market. Majority do not have access to transportation, they lack negotiation skills to close out business contract." (Participant 8)*

Technology and digital awareness

Farmers markets are shifting to ecommerce platforms, they are accessible across geographies, to different race groups and trades happen on global scale. This means that to participate, farmers need access to network connectivity, reliable power supply digital and language literacy. Most of the participants interviewed did not have digital literacy, some could not speak English, they have never used a digital tool such as a laptop previously. These factors would make it impossible for these rural farmers to participate in the activities such as livestock auctions. The participants who know about digital markets had not experience of trading on the platforms.

Perceived inhibiting factors of digital technologies

Lack of capital investment

Six of the thirteen participants mentioned that lack of capital would inhibit them from using digital technologies. There is perception amongst the participants that digital technologies would be expensive to buy and maintain over a period. Another insight that came through during the interviews is that participants have perceptions that the government is not as supportive to subsistence farmers in the rural areas and as a result they are not able to grow their yields.

> *"Lack of financial resources inhibits us as small farmers to adopt digital technologies. Technology such as CCTV cameras are expensive to install and maintain. These require power to operate however we have shortage of electricity. To supplement electricity shortage, we will need to resort to other power alternatives which are also very costly. Department of Agriculture's lack of support to subsidise subsistence farmers affects our farming negatively." (Participants 1)*

Lack awareness and understanding

Five of the participants mentioned that they do not have any reasons to be against adopting digital technologies. They said that they were not aware that these innovations existed and now they would like to know more about them and how to use them.

One participant indicated that they do not know about digital technologies however they are not interested in adopting them because he believes in the traditional ways of farming.

> *"I do not know anything about technology, and I do not think it will work. I believe in traditional ways of farming." (Participant 9)*

Another participant mentioned that technologies are invasive and prone to easy manipulation and for that reason he is sceptical to adopt them into his farming practise.

> *"Technology can easily be manipulated and stolen. It is prone to insider vandalism or breach. I have witnessed employees at the farm cutting connectivity to the monitoring cameras to steal livestock. in other instances, employees were caught stealing and although the farmer had insight of what happened, working relationship and trust were negatively impacted." (Participant 3)*

There is perceived resistance to digital technology adoption from older farmers.

> *"I would be happy to adopt technology. My challenge is that the practice belongs to my father, and he does not understand technology and the role it can play to assist us in farming better. There could be resistance from him." (Participant 7)*

Proposed solutions

Some of the key infrastructure challenges which the participants have highlighted in the interviews included lack of road and network towers, lack power lines and running water, and farming lands.

Public private partnerships

Most participants indicated that partnerships between local communities' leadership, private sector and government plays a critical role in address the infrastructure challenges in rural farming communities. They mentioned that the following should be prioritised to facilitate full digitilisation in their communities.

Rural development: Participants mentioned that government should allocate sufficient budget towards rural development economy. Department of Water and Sanitations should invest in building dams and boreholes in water scares farming communities. Department of Transport should build roads which connect the rural communities to the cities. The department also has the responsibility to ensure that fence is placed along the servitude of the local and municipal roads in the farming communities to curb the high rate of fatal car accidents caused by the livestock that is left to roam without human supervision.

> *"There is need for partnerships with key players such as government, municipality, Department of Agriculture and Economic Development to build and maintain roads, provide water by building dams. Organisations*

> *such CSIR, Vodacom and other Internet and Communication and technology (ICT) providers can invest in building network infrastructure." (Participant 1)*

The participant also mentioned that land is a critical infrastructure in farming as economies of scale drive profitability. He said that farmers should be allocated bigger land to expand their farming practices.

> *"Traditional/ Tribal authorities such as Ingonyama Trust should allocate land to small farmers to farm at a larger scale. Banking institutions like Ithala can fund the small farmers by assisting the with investing in digital technologies." (Participant 1)*

Network connectivity: Most of the participants mentioned that Information Communication and Telecommunication (ICT) companies should invest in building network towers in the rural communities. Interconnectivity is a fundamental characteristic of digital technologies, there is elevated level of dependency on the diverse types of technologies such as IOT devices, machine learning and blockchain to achieve successful execution. Integration and coordination in the agriculture value chain players such as farmers, processors, distribution, and markets are all dependent on network connectivity which relies on stable source of energy hence it would be impossible to achieve full digitalisation in the rural farming KZN when the development of these infrastructures is not prioritised.

> *"Partnership with ICASA to facilitate installation of network towers in the rural areas. Most of the digital technologies are dependent of network signal availability. Partnerships with government and department of agriculture. Power plants can be built to assist with the current power*

scarcity. This can enable subsistence farmers to have Borehole water which can be used for farm irrigation and livestock wellbeing." (Participant 4)

"There must be investments towards alternative power supply to deal with electricity shortage. This may come at a high cost when may need farmers to collaborate with alternative power supplies to fund and support the initiative" (Participant 2)

Digital literacy campaigns

There was a perception amongst most participants that digital literacy is a challenge amongst, government and traditional leaders, subsistence farmers and the public in rural farming communities. They highlighted that the lack of awareness leads to digital technologies not being prioritised during planning and budgeting process. The participants suggested the initiation of digital literacy campaigns in the communities to educate stakeholders on digital technology.

"Build awareness about digital technologies and how they can assist in rural agriculture with the local government, traditional leaders and department of Agriculture and the communities. Once there is understanding of the things required to make digital technologies work, the relevant people can prioritise these and build enabling infrastructure." (Participant 12)

4.4 Summary of results and findings

The interviews revealed that subsistence farming is an ancient practice in the rural communities of KwaZulu Natal and it still an integral part of their sustenance. There is an immense pride and sense of ownership amongst the farmers, and

they have intensions to continue the farming legacy through generations to come. Most of the subsistence farmers in these communities can be catagorised under LSM 1- 4.

The study revealed that there is minimal awareness of digital technologies and their capabilities in transforming agriculture. Although some participants had some level of awareness and capabilities of digital technologies, the possibility of that being part of their farming experience seemed like a distant possibility. There is perception that digital technologies are expensive and require digital literacy to operate.

The interviews revealed that issues such as livestock and crop theft, lack of access to farming land are prevalent in these communities and the farmers do not have the required resources such as capital and security to deal with the challenge. The interviews revealed that roads, power supply, water, literacy, and lack of capital investment were the main potential inhibitors of digital adoption in the rural areas. They further revealed that collaboration with key stakeholder such as government, NGOs, private businesses was needed to fast track infrastructure development which would enable full digitalisation and improve the rural economy.

Table 4. Tabulated themes

RQ #	Research Question	Pro #	Proposition	Theme
1	What is the perceived value of the use of digital technologies, in rural KZN?	1	Adoption of digital technologies can transform subsistence farming in the rural communities.	• Perceptions and awareness of digital technologies
2	What benefits will digital technologies have on the rural community of KZN, and how can these contribute to improving agricultural practices and outcomes?	1	Adoption of digital technologies can transform subsistence farming in the rural communities.	• Benefits of subsistence farming • Proposed infrastructure solutions for full digitilisation
3	What are the challenges of implementing and adopting digital farming rural KZN communities?	2	Macro and micro environmental factors have direct impact on	• Socio – economic challenges and digital adoption • Perceived inhibiting factors of digital technologies

RQ #	Research Question	Pro #	Proposition	Theme
			adoption of digital technologies in the rural farming communities.	Enablers of digital technology adoption

CHAPTER 5. PRESENTATION OF FINDINGS

This chapter discusses the main findings from interviews with the participants shared in Chapter 4. These finding will be interpreted in relation to the literature reviewed in Chapter 2 with the objective to prove the propositions and answer the research questions. It seeks to highlight the consistencies and contrary findings to literature and present findings which may have not been discussed in the literature.

Research findings topics

The research findings explored the benefits of subsistence farming in rural KwaZulu Natal, the level of digital technologies awareness amongst the farmers and the communities and the perceptions which exist regarding digital technology adoption. The discussions covered the socio-economic challenges which subsistence farmers experience, technologies that could be implemented to address the challenges and improve the farming practices and experiences in these communities. Additionally, perceived enablers and inhibitors of digital technology were discussed, and participants highlighted several factors which were elaborated on at length. The role Infrastructure development as a strategic enabler for full digitilisation in the rural farming communities was also discussed.

These topics were linked to research propositions which were made in chapter two with the objective of answering the research questions.

5.1 Discussion pertaining to proposition 1

Proposition 1: Adoption of digital technologies can transform subsistence farming in the rural communities.

Awareness and perceived value of digital technologies

The in-depth interviews findings revealed that there were low awareness levels of digital technologies in rural communities. The findings showed that most farmers had not been exposed to digital technologies. Some participants could not comprehend the value of digital technologies in the initial stages of the interviews. The researcher had to provide overview of digital technologies and their application in the context of the participant's environment. Following this exercise, the participants indicated that there would be value in adopting digital technologies however they had constraints such as finances and inadequate infrastructure. Literature had highlighted these factors as constraints to digital adoption, Bayer (2018) mentioned that digital technology awareness, poor infrastructure, and high cost of acquiring technology are some of the major barriers which affect digital agriculture adoption by subsistence farmers.

The findings further showed that, participants who had been exposed to digital agriculture had awareness and some had used these technologies in their farming practices, or they had encountered other farmers who had adopted digital agriculture. The participants who had adopted digital technologies revealed that incorporating these into the farming practice had resulted in increased efficiencies in their farming such as improved quality of life of the chickens as the digital lights heaters and lights protect them from the cold.

Adoption of digital agriculture by subsistence farmers plays a critical role in sustaining national agricultural sector and boosting the rural economy. According to Langat et al, (2014), acceptance of digital technologies can effect change to most of the agricultural, socio-economic, and environmental challenges prevalent in the rural communities. The findings revealed that the farmers who had adopted digital technologies had improved efficiencies in their farming practices using technologies such as hydroponics, surveillance and monitoring technologies, and drones.

The findings revealed that adoptions of digital technologies can indeed improve the lives of the rural farmers and their communities however there would need to be interventions

dedicated to building digital awareness as very little is known about digital agriculture in these communities.

Proposed infrastructure solutions for full digitilisation

The findings revealed that emancipation of rural subsistence farmers and digital adoption could be achieved when special focus is dedicated to developing digital enabling infrastructures the communities. Involvement of government and private sector through Public Private Partnerships (PPPs) in driving infrastructure development such as roads, dams, network towers. Fox and Signé (2022) articulated that lack of fundamental infrastructure in rural communities can present challenges for digital adoption. Digital technologies are totally dependent of power supply which in most cases is electricity and network connectivity without which they will not perform to their full potential. When farmers do not have access to consistent power source and the Internet, they will not be able to utilise digital technologies such tools for precision farming, tracking, and monitoring sensors leading to technologies' decreased levels of effectiveness and efficiency.

Findings also revealed that network connectivity, capital investment and access to farming land are some of the key enablers of digital adoption. Most of the farmers are illiterate, they do not have access to funding from financial institutions and mostly, they would not qualify to secure funding to develop and expand their farming practices due to their poor credit profiles.

Discussions pertaining to proposition 2

Proposition 2: Macro and micro environmental factors have direct impact on adoption of digital technologies in the rural farming communities.

Socio – economic challenges and digital adoption

Despite their significant contribution to the agriculture sector, subsistence farmers continue to face challenges due to unsustainable farming methods, inadequate infrastructure and logistics, a lack of modern farming expertise, and the resulting degradation of the soil. Current slow economic growth, high cost of electricity and agricultural inputs, water scarcity, the difficulty in accessing markets and financing, and other factors also hindering the productivity and expansion of subsistence farmers in South Africa. (Matlou, n.d.).

In line with the previous studies, the finding revealed that socio-economic factors such as capital investment, livestock and crop theft, natural disasters due to climate change, technology and digital awareness, access to commercial market, physical infrastructure are the main challenges which impact on the adoption of digital technologies amongst subsistence farmers in rural KwaZulu Natal.

Affordability is one of the main barriers for subsistence farmers in accessing advanced agriculture technologies. This has led to lower levels of productivity and economic activity in small rural farms compared to large scale commercial farms who have the financial capacity to adopt and maintain enabling agriculture technologies for increased operational efficiencies. (Chisasa & Makina, 2012). Findings revealed that most of the subsistence farmers interviewed belonged to LSM 1- 4 category and didn't not have the financial capacity to invest in digital technologies. Farmers are of the view that government should partner with them to subsidise their farming practices. These finding is in line with literature, in many instances, cost of technology has been cited as one of the factors that affect digital adoption. Lack of access to funding is one of the biggest challenges for subsistence farmers in South Africa. Agriculture Development Agency (ADA), and Land bank are some of the initiatives which the government has developed to financially assist farmers in starting and sustaining their farming practises. Although this is the case, subsistence farmers are still disadvantaged compared to commercial farmers because they do not possess the know-how and the capability to access these institutions for assistance or even complete the application process correctly to get the grants. (Tsan et al., 2019).

The findings confirmed that indeed livestock theft is one of the biggest challenges for the farmers in rural KwaZulu Natal. Majority of the participants were livestock farmers and they all alluded that they have lost some of their livestock to theft. This finding has confirmed the reports shared in the literature, according to National Stock Theft Prevention Forum (NSPF), farmers lost more than R2 billion through stock theft over a one-year period between 2018 and 2019. The report further indicated that at least 15000 head of cattle, 500 sheep and 12000 goats, with a combined value of R165 million, were stolen in KZN alone during this time. (IOL, 2020). The findings also revealed that crop theft is also on the rise in communities however not much had been covered around this challenge in the literature.

The findings revealed that the recent floods and heat wave experienced in KwaZulu Natal had devasting effect on subsistence farming in these communities. There has been an increase in livestock deaths and farmers are dealing with new livestock and crop disease which they don't have the knowledge, capability, and resources to manage. Literature highlighted the adverse impact of climate change in rural KwaZulu Natal. (Pickson & Boateng, 2021) revealed that the recent heat wave in KwaZulu Natal has led falling water levels in the local rivers and streams and dams causing drought. The lack of water has resulted in livestock and crop diseases and deaths, decreased crop yields, and high cost of food supplies. This has elevated levels of poverty in the in the rural communities as they are reliant on agriculture for their sustenance.

The findings revealed that farmers in these communities held the believe that traditional herbs could be used to protect their farming practices against factors such a livestock and crop theft and increase the production yields. The researcher gathered through discussions that this was an ancient practise and had been practiced through generations.

Perceived inhibiting factors of digital technologies

Ndhlovu (2021) stated that African agricultural sector is mostly composed of subsistence farmers. Majority of these farmers are in the rural communities, lack the digital literacy and capability needed to adequately utilise digital technologies that can be made available to

transform their farming practices. These factors including limited access to technology pose many challenges for digital transformation agenda for rural farming. There is minimal chance of these farmers accepting and adopting the digital technologies.

According to TAM the findings show inconsistencies in the perceived ease of use as well as the perceived usefulness of the Digital Technologies. This is fuelled by the number of older farmers who resist acceptance and are rooted in cultural beliefs as opposed to the educated younger farmers who are more into commercial farming. The findings revealed that digital awareness and literacy and lack of capital investment where the perceived inhibiting factors to digital technology adoption. Low digital awareness was also noted amongst the literate participants. These were also noted as part of the current socio-economic factors for farmers to adopt digital technologies. Behavioural intentions were also a contributing factor in that it was not clear because majority of farmers questioned the transparency and reliability of data and security. These issues if not addressed and actual documentation provided to ensure technology investment security and future financial benefits for the farmers, actual system use cannot be achieved.

Enablers of digital technology adoption

Globally, the adoption and usage of digital technologies in agriculture is dependent on factors such as physical infrastructure, access to technology, government participation and policies. (Abiri et al., 2023) The findings have identified access to capital investment, network connectivity, reliable power source and digital literacy as some of the main constraints of digital adoption in the rural communities currently, however these were also stated as the key enablers of digital agriculture adoption. While the farmers perceived value of digital agriculture adoption is mostly positive, solutions to their current unfavourable conditions can be brought about by addressing these similar factors. Internet access is a big challenge in rural areas, only less than 30% of adults in rural areas can access internet, the band is very poor, 2G and 3G. through these bandwidths, farmers cannot support most of the digital agriculture tools, communicate through smart devices such as smartphones or access information. (Fox & Signé, 2022)

Generally, subsistence farmers struggle with access to capital, and it is required for them to invest in digital agriculture. Failure to secure funding, makes it difficult for the farmers to advance their practices and to become competitive, they are unable to participant in the digital transformation. The implementation of digital technologies and solutions in agriculture typically require a substantial initial investment which is a challenge for subsistence farmers with limited resources.

Chapter conclusion

The findings were able to answer the research questions. Research proposition 1 aimed at determining that adoption of digital technologies could enable subsistence farming in rural KwaZulu Natal. The findings were able to answer this proposition by revealing that although there was low digital awareness in this communities, the farmers were open to knowing more about digital farming and integrating it into there their traditional practices. There was high perceived value of digital farming amongst the farmers. Although digital technologies had not been adopted into the communities, the farmers had observed the use of digital agriculture tools at other farms and there was a general view that they could improve how they farm provided that their current constraints are dealt with.

Proposition 2 aimed at articulating that micro and macro environmental factors had the direct impact on adoption of digital technologies. The insights derived from research revealed that the current lack of digital agriculture adoption in the communities was due to challenging factors such as access to land, capital, water, reliable power supply and internet connectivity, digital literacy, government and private sector participation and climate change. The findings revealed that resolving these challenges could unlock the great potential in rural subsistence farming and lead to economic growth.

CHAPTER 6. CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the conclusion, limitations and recommendation based on the research questions and propositions introduced in chapter 2. The limitations highlight the matters which could have had impact on the study and potential presented different perspective. The chapter also explores the recommendations are made based on what could be improved to facilitate adoption of digital technologies in the communities.

This research was set out to explore the role of digital technologies in enabling subsistence farming in rural KwaZulu Natal

Research sought to answer the following questions:

1. What is the perceived value of the use of digital technologies, in rural KZN?
2. What benefits will digital technologies have on the community of rural KZN, and how will it contribute to improving agricultural practices and outcomes?
3. What are the perceived challenges of implementing digital technologies farming solutions in the of rural community KZN?

6.2 Conclusion regarding research propositions

Proposition 1: Adoption of digital technologies can transform subsistence farming in the rural communities.

Based on the literature review and research findings, it was revealed that adoption digital technologies can transform agricultural practices and improve the efficiencies even in rural

communities. IoT Digital agriculture is a highly interconnected and dependent practice and for it to be adopted, enabling factors need to be available and efficient failing which its potential cannot be fully realised. Rural KZN consists of a large landscape as well as population second largest in South Africa. This case of economies of scale comes with a large potential of economic growth. However, in this fast-paced digital ecosystem it is not only important to accelerate the adoption of digital transformation, but it is equally important to achieve it incrementally. The ability for digital technologies to transform rural communities lies in incremental introductions of affordable technology. Taking into consideration the revenue generated from subsistence farmers daily, it is apparent that affordability of daily necessities is limited. Great potential in economic growth is displayed in the population numbers but not in the financial and digital inclusion. Government initiatives require a more focused approach in narrowing the digital divide by means of digital awareness building campaigns such as radio interviews, television, outdoor digital screens, collaborations for advertisements and competitions to engage the communities and spread the word on the affordable products to gain brand awareness as well as increase acceptance and adoption possibilities within communities.

Proposition 2: Macro and micro environmental factors have direct impact on adoption of digital technologies in the rural farming communities.

To analyse any industry, it is crucial to examine the internal and external environmental factors and the effects they may have in achieving required objectives. Macro environmental factors are largely based on the PEST, which is the aspects of politics, the economic, social and technological effects. These factors can provide insights that are able to assist with analysis and reaching.

To this research, PESTEL was used to include the environmental and legal factors. These factors contribute largely to current effects of global warming and the regulations surrounding the success of the analyses and findings. Agriculture especially in KZN, has been affected by the recent global warming and extreme weather changes that have destroyed crops and killed livestock. This recent global environmental challenge has forced

the acceleration of adoption of digital technologies to secure existing contributions to the country's GDP as well as the opportunity to trade in wider markets around the globe. Micro environmental factors which are termed internal factors exist concurrently to form a unified deduction of potential impacts. These factors then determine whether the analyses or research can assist in formulating strategies for digital adoption. This research has evidenced that the macro and micro environmental factors have had a direct impact on the adoption of digital technologies in rural KZN.

This conclusion is based on the findings that shows Political unrest in KZN as well as power dynamics within the traditional leaders causing conflicted ideas. The issue on the ownership of land by the traditional leaders and not the farmers which then causes reluctance in adoption of digital technologies in land that is not owned by the farmer who intends to add value to the property by adopting digital technology. The other challenges on the Technology infrastructure that has produced slow service delivery. The slow adoption and acceptance are also fuelled by lack of digital resources. Other factors that can cause scepticism are around the security and protection of data as well as visual scrutiny. The factors can cause a direct impact on the adoption of digital technologies especially on majority of uneducated farmers.

Practical analysis of the findings

PESTEL ANALYSIS/SWOT

PESTLE analysis is an instrumental framework that is utilised to identify and evaluate external factors that impact an industry or organization. Political, economic, sociocultural, technological, legal, and environmental aspects are the sources of its title. This analytical tool is essential for providing organizations with understanding of the macro-environmental factors that have the capacity to impact their operations and need the development of measures to mitigate such effects. PESTLE analysis is a useful technique for organizational development when combined with SWOT analysis (strengths, weaknesses, opportunities, and threats) This combination helps evaluate an organization's potential for growth or

decline as well as its capability, strategic direction, and existing situation. According to Benzaghta et al. PESTLE analysis expands the scope of a business's study by considering external factors that are frequently outside its control, whereas SWOT analysis focuses mostly on internal factors. As such, the combination of PESTLE and SWOT studies provides a more comprehensive understanding of the business ecosystem.

In the case of this research, it is important to analyse the macro and micro environmental factors to understand the challenges faced by farmers in rural KZN with regards to enabling digital technologies in the province but more so in their communities.

PESTEL/SWOT	STRENGHTS/OPPORTUNITIES	WEAKNESSES/THREATS
Political	• Inkatha freedom Party (IFP) has majority seats (80) in KZN • Increased focus required on digital transformation with new government initiatives i.e. the digital transformation strategy for 2020-2025 • Improved coordination and integration among government departments post covid-19 • Increased focus on service delivery by the government, infrastructure plans	• Political instability • Monarchy (traditional leaders) and government not in unison • Long-term ruling party consisting of senior citizens with no fresh young ideas.
Economic	• KZN is the Second largest contributor of economy after Gauteng with 35.25% GDP	• Farmers financial constraints regarding acquiring digital

	• Digital infrastructure will Promote economic growth • Government Subsidy to fund farmers will increase productivity and economic growth	equipment maintenance and security • Lack of foreign investments • Unemployment rates and minimum wage issues
Social	• Working closely with the community to eradicate livestock theft • Monitoring social trends • Community based digital technology awareness programmes available • building an inclusive digitalised society • Opportunities for skill development and entrepreneurship	• Low levels of education in the majority of farm owners • Gender inequality • Human labour threats • Food security • Eradicating cultural farming methods and beliefs
Technological	• Digital transformation strategy for 2020-2025 for KZN province • Infrastructural upgrade regarding electricity and power lines and cell phone towers • Digital transformation will assist in increase in technology literacy • Government focus on narrowing the digital divide • increase in digital projects within the province	• Lengthy time frames in dealing with repairs and restoring of power • Cyber security risks • Slow adoption and acceptance • Lack of Ease of use

	• possible increase in accountability transparency and efficiency of farmers • 11 million people in KZN province and only 1.8 million have access to internet	
Environmental	• Reduction of emissions when using digital technologies • Tracking of any diseases or life cycle monitoring of crops • Management of climate change • Diverse geography	• Water supply issues affecting the supply of electricity in the province • Extreme weather conditions
Legal	• Legislation power is shared with political party and national parliament especially around agriculture • Opportunity to align agricultural policies with Artificial Intelligence policies.	• Climate regulations • Land ownership and fragmentation • Data protection POPIA Act violation • Intellectual property issues • Farmers and employee rights and scrutiny whilst using digital technology

6.3 Limitations of the study

The study focused on the role of digital technologies in enabling subsistence farming in rural KwaZulu Natal. It did not explore commercial farming however it is understood that the challenges and solutions identified through the study can be applied across all scales of farming.

Although the use of digital technologies has become a game changer in innovation, its ethics have not been properly documented. There are no proper guidelines on data integrity and can be biased due to systems developed in other countries that may not understand rural South African setup.

The study was conducted in specific rural communities, perhaps expanding the sampling size could have given another perspective.

Some of the participants who had initially agreed to the interview were unavailable at the agreed time, researcher had to find other participants, and this impacted on the research timelines.

Loadshedding and network connectivity became a challenge during the interview, as a result, some interviews had to be rescheduled.

Literacy levels and English proficiency became a barrier in some instances. The researcher had to find and interpreter as the participants could only understand and speak isiZulu.

Some of the interviews had to be rescheduled because poor conditions of access roads to the communities due to heavy rains.

6.4 Recommendations

Government should prioritise the development of digital enablers such as energy and transportation infrastructure to facilitate integration of digital farming to the traditional farming practices in rural KwaZulu Natal.

Financial institutions should be more flexible in their lending criteria and tailor products that are aimed at empowering rural subsistence farmers.

Traditional leaders and local government should partner with and NGOs to fund the literacy campaigns which will be dedicated to educating rural subsistence farmers and general community members to build awareness about the role of digital technologies and their use in agriculture.

Agri-SETA should invest in educating rural unemployed youth about digital agriculture and assist them with setting up and funding agriculture focused start-up initiatives and co-operatives. This will assist with eradicating poverty within the communities while upskilling the youth.

Transparency of government and traditional leaders is crucial in gaining trust of the communities and trusting the landowners with their financial and technical investments. This will increase local partnerships and synergies and therefore boosting productivity.

6.5 Suggestions for further research

The idea of digitalising agriculture in KZN is already a government initiative that has been under way since 2020 according to the KZN Digital transformation strategy 2020-2025. Taking into consideration the events of 2020 that have involved Covid-19 and a 2 year pause on the plans and rollout of the Digital Transformation Strategy plan. This 2-year delay has meant that technology infrastructural upgrades have not yet taken place but still

optimistically underway. This effort is crucial in that it creates a sense of ease and readiness for farmers and communities to adjust to or rather incorporate into their day-to-day farming.

For further research, I think it is important that the research is specific in its technology i.e. smart watch. This will allow the farmers to adapt to incremental ideas as opposed to technologies that are either too expensive, complicated and lack ease of use.

The other factors that need consideration are around introduction to digital technology that may conflict traditional beliefs. Instead, it would be advisable to consider smart affordable technology that can be incorporated into their tradition. Further topics that could be considered could be around cultural impacts on digital technologies and Impacts of slow adoption of digital technologies in rural arears. These topics could give an opportunity for the researcher to really dive into different cultural beliefs in different rural arears of South Africa.

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APPENDIX A Participant Information Sheet

Dear Sir / Madam

My name is Mamakhethe Zulu I am a Masters student in Digital Business at the University of the Witwatersrand, Johannesburg. My supervisor is Dr Ayanda Magida I am conducting a research study about Digital Technologies. The study title is The role of digital technologies in enabling subsistence farming in rural KwaZulu Natal

I am inviting you to take part in an interview and answer a questionnaire. If you decide to take part, your participation in this research study will last about one hour. The completion of the questionnaire will take place at your place at in the month of July 2023

With your permission, I would like to audio record the interview. This data will be stored in One Drive for five years and/or deleted after five years. Only Mamakhethe Zulu will have access to the data.

During the research activity, I will need to ask for some personal information about you, including contact details such as mobile phone number and email address.

The interview will be confidential and anonymous. When I share the results of the research study, I will not include your name or anything else that could identify you. With your permission, other researchers may use the data collected from this research study, but your name and any personal information will not be used or passed on.

If you decide to take part in the research study, it should be because you want to volunteer. You do not have to take part. You can stop being in the study at any time. You do not have to answer any questions if you do not want to. You will not get any direct benefits if you choose to join the research study. You will not lose any services, benefits, or rights you would normally have if you decide not to join. Taking part in the research study will not cost you anything. You will not be paid for being in this research study.

The risks for this research study are no more than what happens in everyday life / some of the questions asked may make you feel sad or upset.

This research study will be written up as a research report. The report will be available on the university library website. If you would like to receive a summary of this report, I will be happy to send it to you.

If you have any questions during or afterwards about this research study, feel free to contact me or my supervisor on the details listed below. If you have any concerns or complaints about the ethical procedures of this research study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za.

Yours sincerely,

Mamakhethe Zulu

Researcher:

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Ayanda Magida, ayanda.magida@wits.ac.za, 011 717 3953

APPENDIX B Participant Consent Sheet

Consent Form

The role digital technologies in enabling subsistence farming in rural KwaZulu Natal

Mamakhethe Zulu

I, ……., agree to participate in this research project.

I agree to the following:

(Please circle the relevant options below)

The research study was explained to me. I understand what this study is about.	YES NO
I understand that I can volunteer to take part in the study	YES NO
I agree that the interview/focus group/other activity may be audio recorded	YES NO
I agree that direct quotations from my interview/focus group/other activity may be used by the researcher in their research report/ manuscript/book chapter	YES NO
I agree that my participation will remain anonymous (my name or other identifying data will not be used by the researcher in their research report/manuscript/book chapter)	YES NO

I agree that other researchers may use the information I provide in my interview/focus group/other activity (depending on their own ethics clearance being obtained) but my name and any personal information will not be used or passed on	YES NO

…… (signature)

…… (name of participant)

…… (date)

……Mamakhethe Zulu…… (signature)

……Mamakhethe Zulu…… (name of researcher/person seeking consent)

……30 June 2023…… (date)

APPENDIX C Interview Guide

Research topic: The role of digital technologies in enabling subsistence farming in rural KwaZulu Natal

Questions

1. Which gender identity do you identify with?
   - Male
   - Female
   - Other

2. Which age group do you belong to?
   - 15 years to 25 years
   - 26 years to 35 years
   - 36 years to 45 years
   - 46 years to 55 years
   - 56 years and above

3. What is your level of education achieved?
   - Grade 12 and below
   - Degree level
   - Postgraduate

4. Where in KZN are you based?
   - Northern region
   - Southern region
   - Eastern region
   - Western region

5. Can you tell me about yourself and the kind of farming you do?
6. How long have you been involved in the farming?
7. What have been the benefits of subsistence farming?
8. Have you considered using technologies to enhance your farming experiences…if so what technologies have to used?
9. What are the socio-economic benefits and challenges subsistence farmers in KZN face and how can the use of digital farming solutions address those challenges?

10. How do we solve or address limitations of advanced infrastructure to achieve full digitalisation?