USE OF MOBILE PHONES BY SUBSISTENCE FARMERS IN THE KINGDOM OF ESWATINI: A DESIGN SCIENCE RESEARCH

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Abbreviations and Acronyms

DSR – Design Science Research

ESWADE – Eswatini Water and Agricultural Development Enterprise

MoA - Ministry of Agriculture

SMLP – Smallholder Market-Led Project

Definition of Terms

Inkhundla – an administrative subdivision in Eswatini that is smaller than a region but bigger than a chiefdom

Abstract

Access to information is one of the key ways of assisting farmers to improve their agricultural output, gain access to markets and generate income. Governments, NGOs, Universities and other institutions have volumes of information that can benefit farmers, but lack the means to timeously and easily share this information with the farmers. There exists a large gulf between those that need information and the entities that possess information, and bridging this gap is crucial. The advancement of mobile phones and their high adoption levels by developing countries makes them one of the most ideal means of disseminating information amongst farmers. The use of mobile phones by farmers not only benefits farmers, but also the organizations supporting them by improving the means of communication. This research looks at the effects mobile phone communications has on farmers and the organisations supporting farmers. The use of mobile phones enhances means of communications, improves internal processes within organisations and also ameliorates means of engagement with farmers. This study follows the Design Science Research approach to develop a communications module for a project working with smallholder farmers in Eswatini. The developed artefact is designed to benefit both parties, the farmers receiving the information and the organisations supporting them, the content creators.

1. Chapter One

1.1. Introduction

This chapter introduces the topic under study and outlines the purpose of conducting the research. Section 1.2, 1.3, 1.4 covers the background, the research problem, the research aim, research objectives and research question. The remainder of the study which is section 1.5, 1.6, 1.7 covers the significance of the study, the design strategy and the structure of the thesis.

1.2. Background

Land tenure in rural Eswatini is held mainly through Swazi Nation Land (SNL), this land is held in a trust registered in the King's name on behalf of the citizens. The land is then distributed through traditional structures namely local chiefs appointed by the king. Citizens acquire land through a customary practice called *kukhonta,* whereby the household head pledges allegiance to the chief and in return gets a piece of land to cultivate and build on (Mabuza et al, 2013). A majority of emaSwati (Swazis) reside in the rural areas, they occupy SNL and rely on subsistence farming for their livelihood ("Eswatini", 2019).

Subsistence farming is often characterised by low production and low output, producing barely enough for the families to live on (Muto & Yamano, 2009); (Okello, Kirui, Njiraini & Gitonga, 2012). The low production and low output are often a result of repudiating modern farming techniques and machinery in favour of traditional and old-fashioned practices. The most commonly used methods of land cultivation in Eswatini are draught animals and hand hoes. These techniques are very labour intensive, yet HIV/AIDS has obliterated the labour force in Eswatini; and the agricultural output already compromised by ineffective farming techniques further decreases when less work is done on the land (Mabuza et al, 2013).

Agriculture is an important economic sector for Eswatini and other developing countries because it provides economic and social development as well as food security (Zhang, Wang & Duan, 2016). Eswatini government has put a lot of effort towards developing the agricultural sector and combating high levels of poverty in Eswatini. Over 70% of the nation lives in poverty and has difficulty participating in the economy. This problem is further exacerbated by the HIV/AIDS crisis which has rendered a lot of the eligible workforce unable to work ("Eswatini", 2019); (MOAC, 2005); (CSO, 2010). With SNL being registered in a trust under the King's name, the occupants of the land cannot use it as collateral for financing, and this makes it difficult for rural farmers to procure essential inputs for their farms. In a bid to assist farmers, the government set up programmes (e.g. Rural Development Area Programme - RDAP) to help rural farmers access subsidized inputs and tractors (MOAC, 2005); (Mabuza et al, 2013). Although initially effective, problems have plagued these programmes ever since government started experiencing financial constraints. As a result, rural residents struggle to escape from the clutches of poverty as they cannot utilise their resources effectively and gain economic benefit from them (Sife, Kiondo & Lyimo-Macha, 2010). In addition, the RDAP was supposed to be an information hub for farmers, providing expertise and advice to rural farmers on how they can improve their agricultural output (MOAC, 2005), however, this program mostly benefits residents closest to it. Rural residents who live far from the RDAP need to travel long distances to get the information. Thus, they often opt to receive farming tips from family, friends or other residents. Access to latest information is vital as farmers can learn new techniques that could potentially increase their agricultural yield; and increased yield translates to farmers

having enough produce to consume and sell for profit (Das, Basu & Goswami, 2012). True, government has adopted various information dissemination means such as agricultural radio shows, newspaper articles and distribution of informative pamphlets, but the effectiveness of these means has not yet been measured to get a clear indication of their benefit to the target audience.

Developing countries have widely used Information Communications Technology (ICT) in agriculture to reach residents far away from local information hubs. The adoption of mobile phones in developing countries has outpaced other forms of ICT; mobile phones have reached even the most remote rural areas (Butt, 2015). The ubiquity of mobile phones in developing countries stems from that they are intuitive, easy to maintain and boast of several options to facilitate communication and information exchange (Adamides & Stylianou, 2013); (Butt, 2015); (Furuholt & Matotay, 2011). Researchers have done an exhaustive study on mobile phones, their adoption by rural residents, their application in agriculture and their effectiveness in disseminating information. Some of the example studies are (Das, Basu & Goswami, 2012); (Adamides & Stylianou, 2013); (Butt, 2015); (Furuholt & Matotay, 2011); (Katengeza, Okello & Jambo, 2011); and this list of studies barely scratches the surface of the available information. A number of the studies look at the phenomena from two aspects, the mobile phone and how it is an effective tool for information dissemination and also the benefits farmers receive from the use of mobile phones in their agricultural endeavours. Farmers need a credible source of information like a government agency or a university to provide them with reliable information in order to make critical decisions (Gichamba, Waiganjo & Orwa, 2015). Unfortunately, the available literature does not look at the perspective of the entities providing farmers with information and how they are impacted by the farmers' use of technology. The government of Eswatini has not extensively utilised electronic communication to disseminate agricultural information. This study aims to look at how the use of text messages, commonly known as SMSs can be used to disseminate information to farmers to help improve their agricultural output. Since mobile phones are widely available and SMS are relatively easy to use, this paper looks at how the use of SMS can benefit rural farmers in the Kingdom of Eswatini. The paper focuses on both the farmer who will receive the information and the content creators. That is, how the use of SMS helps content creators better interact with farmers. The study looks at both the creator of content and the consumer because both parties are equally important, yet differently affected by farmers' adoption of mobile phones.

1.3. Context of the Study

The Smallholder Market-Led Project/Climate Smart Agriculture for Resilient Livelihoods (SMLP/CSARL) is a project in the portfolio of other projects under Eswatini Water and Agricultural Development Enterprise (ESWADE). The SMLP is focused on "reducing poverty and food insecurity through an investment supporting increased agricultural production, productivity and commercialization of smallholder agriculture while maintaining a sustainable and resilient environment" ("ESWADE", 2019). ESWADE is a parastatal under the Ministry of Agricultural (MoA) in Eswatini and its focus is on implementing agricultural projects for MoA. The project baseline survey shows the potential number of households to be impacted by the project are about 15 300 with a population of approximately 80 900 persons. The population is engaged by a staff complement of about 16 employees working in the communities. Staff members that work with communities in the field are; Community Development Specialist (1), Sustainable Agriculture Coordinator (1), Livestock Coordinator (1), Community Development Officer (5), Livestock Officer (4), Sustainable Agriculture Officer (4). Other staff members perform a supporting function and do not interact with the community members. The mandate of the project is achieved through farmer

education, demonstrations, training manuals, provisions of starter packs (seeds, vaccinations), expert advice, market linkages through the facilitation of market days, negotiations with vendors for supplier contracts on behalf of the farmers and dissemination of other information. The large scale of the project coupled with the limited staff that needs to reach the vast farmer population, requires an improved way of engaging with farmers for the project to achieve maximum impact.

1.4. Research Problem

Poverty is a widespread problem in developing countries particularly in rural areas where there is a high reliance on agricultural production. Market participation of farmers can reduce poverty by increasing their net returns from agricultural produce (Muto & Yamano, 2009). Markets often fail in most developing countries for several reasons, but chief among them being lack of information (Katengeza, Okello & Jambo, 2011). Market Information System (MIS) are typically developed to disseminate market prices and other information to farmers and address issues of information asymmetries between farmers and traders (Wyche, Densmore & Geyer, 2010). The advancement of ICT, particularly mobile phones has increased the potential to support the dissemination of information to rural subsistence farmers (Owusu, Yankson & Frimpog, 2017). Information dissemination is critical not only to farmers and traders but also governments and other farmer supporting agencies and organisations. Advancements in these technologies also impacts the way these organisations operate and impact their engagements with farmers.

Mobile phone penetration has spread widely in developing countries, with people having access to mobile phones more than any other technology (Tadesse & Bahiigwa, 2015). The International Telecommunications Union (ITU) estimates that as of 2018, mobile phone subscriptions in Eswatini were 1 052 000 or 93.53 subscriptions per 100 inhabitants (“Statistics”, 2019). These statistics show a large level of mobile penetration in Eswatini, making the case for mobile phone adoption in farming because of availability and use. The impact of mobile phone use in agriculture is extensively discussed in literature, but mainly focusing on the farmers and how they gain access to markets (Wyche, Densmore & Geyer, 2010). The studies focus heavily on the content consumers and how receiving information has benefited them. Focusing on farmers has left a gap on the effect mobile phone adoption has on content producing organisations and how availing a platform for them to reach farmers has benefitted them. This study looks at the information dissemination from both perspectives, the benefits for the farmer and also the impact the organisations supporting the farmers can have through a platform to reach the farmers. The gap is addressed through the development of an SMS based platform to disseminate information to farmers.

1.5. Research Aim, Research Objectives and Research Questions

1.5.1. Research Aim

This study aims to develop and evaluate an SMS based information dissemination platform that will enable organisations to better engage and support rural-based subsistence farmers.

1.5.2. Research Objectives

The objectives of this study are as follows:

1. To understand the typical information needs of subsistence farmers in Eswatini
2. To understand the available means of information dissemination.
3. To understand the typical means of farmer engagements by organisations authorised to work with them.
4. To develop an SMS based messaging system to disseminate information that will be beneficial to both content producer and content consumer.
5. To evaluate the developed artefact in supporting the needs of both the farmer and the supporting organisation.

1.5.3. Research Questions

A primary research question has been formulated as a guide to help achieve the objective of this study.

1.5.3.1. Primary research question

How can organisations supporting farmers use an SMS based messaging system to improve farmer engagement and information dissemination?

The primary question along with the research objectives gives rise to the following secondary questions:

1.5.3.2. Secondary research questions

1. What information needs do subsistence farmers have?
2. How do farmers gain access to this information?
3. How do organisations authorised to work with subsistence farmers typically engage with the farmers?
4. How can a SMS based information system that supports both the needs of both content producer and consumer be developed?

1.6. Significance of the Study

The finding and the artefact developed in this study can be important to a number of different organisations, groups and institutions. Farmers are one of the main beneficiaries of this study. This group benefits from receiving information that can be helpful to their agricultural production and output. This will also allow them to get information and ask questions without leaving their farms. Farmers can save a lot of money if they use their mobile phones to search for information.

Also, NGOs and other institutions can benefit from a simplified way of disseminating information that reaches a much larger group of farmers all in one go. SMS can be used as an extra means of reaching farmers coupled with their day to day interactions with rural inhabitants. Governments can also take a leaf from the success experienced by the farmers and NGOs. The successful use of ICT to reach farmers will show government the need to incorporate ICT in their policies and programs for rural development. The use of SMS to reach farmers is just a small part of the role ICT can play in using ICT in agriculture. With ICT being so board, several different uses can be thought out to widen the reach of farmers and improve the productivity of rural agricultural production. Lastly, a final group that can also benefit from this study is academia. The academic community can benefit from the addition to the knowledge base that will come from this study. The new perspective of looking at both content creators and content consumers adds a different element to the knowledge base that has been widely studied.

1.7. Design Strategy

This study employed the design science research (DSR) method to achieve the aim and objectives set. The framework was proposed by (Hevner et al, 2004) and is discussed in more detail in chapter 2. The process followed to conduct the research is from (Offermann et al, 2009) and is discussed in more detail in chapter 2. Literature review and interviews with both farmers and subject matter experts (SMEs) were done to identify the problem needs. The design of the artefact was done through further literature reviews and engagements with SMEs. The prototype was tested through engagements with a small group of farmers.

1.8. Structure of the Thesis

This paper is divided into eight chapters, divided as follows:

Chapter 1 – Introduction
This chapter introduced the background, research problem, aim, objectives, question, the significance of the study and design strategy. In summary, the chapter points out that even with the plethora of information on the benefits of mobile phone use in agriculture, there exists a gap in parties that are affected by the use of mobile phones in agriculture. The organisations that create the content consumed by farmers have not received a lot of attention because the findings heavily focused on farmers alone.

Chapter 2 – Literature Review
This chapter presents the literature of the study. The literature not only presents the current landscape of the studied field but also forms part of the research process being followed (Offermann et al, 2009). The chapter helps with problem identification as well as the determination of an appropriate solution to solve the problem identified.

Chapter 3 – Theoretical Framework
This chapter explores a theoretical framework that guides this study. Since this paper looks at both the farmers and a parastatal supporting the farmers, two models are explored, the Unified Theory of Acceptance and Use of Technology (UTAUT) model as well as the Mobile Phone Technology Adoption Model (MOPTAM) model.

Chapter 4 – Research Design
This chapter provides details on the methodology used in this paper. The chapter covers topics like research strategy, sampling techniques, data collection methods and techniques ensuring the validity of the data.

Chapter 5 – Problem Identification
Problem identification follows the steps suggested by the research process proposed by Offermann et al (2009). These steps include a review of the interviews with farmers and subject matter experts, a review of the literature and an evaluation of the problem that the study is attempting to solve.

Chapter 6 – Solution Design
The solution design also follows the steps in the Offermann et al (2009) research process. This chapter discusses the proposed SMS based communication system and its development and the different iterations of the development.

Chapter 7 – Evaluation
The evaluation chapter discusses the results of the research. The evaluation looks at the suitability of the proposed solution for the problem being solved. Feedback from different stakeholder is sought to summarise the results of the entire process.

Chapter 8 - Conclusion
The final chapter summaries the findings and conclusions based on the finds. The research limitations and recommendations for further research studies along with the contributions to literature made by the study are also discussed.

2. Chapter Two – Literature Review

2.1. Introduction

This section describes the literature reviewed in the study. The literature is relevant to the research questions posed and helps in getting closer to answering the research questions. The chapter is broken down into 4 sections, namely; Subsistence Agriculture in Developing Countries, Role of Information in Subsistence Agriculture, Mobile Phones in Agriculture, Design Science Research. This chapter seeks to understand how subsistence agriculture is currently being practiced in most developing countries. This chapter also looks at the role information plays in subsistence agriculture and how information reaches subsistence farmers. The chapter closes off with two sections; mobile phones in agriculture and the design science research (DSR). The last two sections look at the different ways in which mobile phones have benefitted farmers in agriculture. The final section reviews literature on design science which is adopted and is the main topic of the study.

2.2. Subsistence Agriculture in Developing Countries

The most basic definition of poverty is commonly given in terms of a measurement of income or the amount of money an individual or family can spend per day. It is acknowledged that poverty goes beyond the basic definition and encompasses non-material aspects like vulnerability, powerlessness and denial of services or opportunity (Sife, Kiondo & Lyimo-Macha, 2010). The definition of poverty also extends to lacking means, resources, information and communication channels to convert one's resources into income-generating activities (Sife, Kiondo & Lyimo-Macha, 2010). Poverty is exacerbated for rural women as they are denied some of the basic privileges afforded to men. Men are the dominant owners of assets which makes women less endowed, and women experience high levels of illiteracy due to low levels of education (Katengeza, Okello & Jambo, 2011); (Martin, Abbott, 2011). High levels of illiteracy and lack of assets (credit, agricultural inputs, land) are the major factors that condemn women to poverty. Women lack the very basic resources that can help them navigate their way out of poverty (Martin, Abbott, 2011). Some cultures remain so patriarchal that studies cannot be done with both men and women sitting in the same group as their beliefs do not allow these sexes to sit in one gathering (Gichamba, Waiganjo & Orwa, 2015). Escaping a life of poverty is challenging when faced with limited resources, and this can be exceptionally difficult for women who get fewer resources because of their sex.

Agriculture is commonly recommended as one of the quickest routes to escape a poverty-stricken life (Muriithi, Bett & Ogaleh 2009); (Muto & Yamano, 2009). Though the solution sounds straightforward, the execution is a bit more involved because farmers contend with a number of challenges in order to obtain positive results from their agricultural pursuits. Agriculture refers to practices such as land cultivation and animal breeding to produce food. The agricultural sector is a pillar of a lot of developing countries, often being the largest employment sector providing income, food security and economic development (Zhang, Wang & Duan, 2016); (Idrees et al, 2019); (Rao, 2007). Subsistence farmers in Africa, mainly rural inhabitants producing for their household consumption, produce a bulk of the food consumed on the continent yet they remain income poor (Muriithi, Bett & Ogaleh 2009); (Kehinde & Agwu, 2015); (Muto & Yamano, 2009). Subsistence farmers are characterized as rural residents owning a small piece of land, usually coming from a large family, whose primary occupation is food production (Wyche, Densmore & Geyer, 2010). The use of primitive tools and simpler farming techniques often results in low production and low agricultural output, leaving the farmers with barely enough for their families to survive on (Muto & Yamano, 2009); (Okello, Kirui, Njiraini & Gitonga, 2012); (Panin & Hlope, 2013). As such, farmers

need to increase their produce and market participation to make an income from agriculture (Muto & Yamano, 2009). An increase in productivity and income can be achieved through embracing and utilising improved technologies, gaining access to appropriate, timely and accurate information, obtaining knowledge on new production techniques and accessing markets (Munyua, Adera & Jensen, 2008).

However, many factors make farmers disregard new farming techniques and technologies, and thus remain subsistence farmers. Some of the farmer specific characteristics include gender, age, education level and size of household (Katengeza, Okello & Jambo, 2011). Users who have more years of education show traits of more skill and knowledge and are more likely to adopt new technologies (Katengeza, Okello & Jambo, 2011). Literate farmers are more aware of new technologies and farming techniques, which increases their likelihood to adopt technology. This is often seen in educated younger male respondents (Katengeza, Okello & Jambo, 2011). Other factors that influence the adoption and use of new technologies and farming techniques are not specific to the farmer like distance to market, farm size, access to electricity and distance to extension office (Katengeza, Okello & Jambo, 2011), (Tadesse & Bahiigwa, 2015). The distance to market influences a farmer's decision to adopt technologies such as mobile phones. Farmers use mobile phones to call and enquire about market prices and save money, as opposed to travelling with their goods to different markets trying to find the best price (Katengeza, Okello & Jambo, 2011); (Tadesse & Bahiigwa, 2015); (Owusu, Yankson & Frimpog, 2017). Access to electricity influences the type of technology the farmers can use. Mobile phones are more likely to be adopted in areas with scarce electricity because they are powered using a battery (Wyche, Densmore & Geyer, 2010).

Environmental factors also make it difficult for farmers to produce optimally. Given the pace at which the climate is changing challenges such as erratic rainfall, floods, droughts and excessive temperatures make it difficult to have a consistent harvest (Munyua, Adera & Jensen, 2008); (Christensen et al, 2019). Gaining access to resources in order to conduct work on the farm also adds to the complexities experienced by farmers. Illnesses such as HIV/AIDS and rural to urban migration limit the availability of animal, mechanical and human resource. (Munyua, Adera & Jensen, 2008); (Mabuza et al, 2013). The farmers themselves often lack the resources or knowledge to invest in their farms and rely on outdated and manual cultivation techniques (Muriithi, Bett & Ogaleh 2009). Institutional problems also pose a challenge to the productivity of farmers and the government needs to invest infrastructure that will facilitate trade between buyers and sellers. Improvement in road and transport infrastructure, policies and markets, communication networks, access to government programmes and incentives and other government support, all have drastic impact on the farmer's ability to better produce and improve their livelihoods (Munyua, Adera & Jensen, 2008); (Muto & Yamano, 2009); (Zhang, Wang & Duan, 2016). Governments also need to put in place policies and structures that make it easy for farmers to own or obtain a title for their land to be able to use this as collateral with lenders (Christensen et al, 2019).

Lack of agricultural information has been one of the major factors that have contributed to subsistence farmers' inability to grow from small scale farmers to commercial agriculture (Okello, Al-Hassan, Okello, 2010). Farmers need to be educated on how to increase their farm productivity and how to address the challenges that hinder them from producing for profit. Government-led initiatives and other authorised stakeholders can train and share knowledge with farmers to yield production improvements (Gilani et al, 2019). Some of the programs need tailoring in order to address needs of farmers in different locals. Government programs are often developed using a top-down structure, developed at the ministry level and then trickling down to the regional offices and

then the farmers (Zhang, Wang & Duan, 2016); (Mabuza et al, 2013). However, availing and structuring information to suit the different needs of individual farmers can alleviate numerous farming challenges. Information, thus, becomes an important commodity and resource farmers need to navigate their way out of poverty.

2.3. Role of Information in Subsistence Agriculture

Information and knowledge are strategic resources and are transforming the world economy and playing a critical role in ensuring sustainable development (Adamides & Stylianou, 2013); (Kehinde & Agwu, 2015). Information of reasonable quality is required to see an improvement in all the different areas of agriculture (Zhang, Wang & Duan, 2016). Competition and market success are bolstered through availability and adequate access to information. Information increases transparency and the level of trust amongst trading partners, thus improving the level of economic transactions (Katengeza, Okello & Jambo, 2011). Beyond just the scope of agriculture, information and knowledge are recognised as a strategic resources and important factors for performance, competitive advantage and operational success (Vangala, Banerjee & Hiremath, 2017); (Kehinde, Agwu, 2015). Information is as essential and critical as capital, infrastructure, labour and skills (Mtega, 2012). A lot of the challenges that inhibit farmers from increasing their productivity can be addressed through education and access to information. Information provides the fuel necessary to invigorate efforts of agriculture in the fight against poverty in developing countries.

The benefits of having information are almost innumerable and greatly reward the person that possesses it, on the other hand, the inability to access information comes at a high cost to the deprived individual. One of the major contributors to a farmer's inability to transition from subsistence to commercialised farming is lack of information (Okello, Al-Hassan, Okello, 2010). Farmers are not able to adopt profitable production alternatives because they lack the know-how and information to do so. Ignorance also traps them in a rut of supplying low-paying markets, thus perpetuating their poverty (Okello et al, 2010). Information is required throughout the production process, but it is towards the point of trading the goods where farmers lose out the most due to information asymmetry. Knowledge of market prices gives farmers better negotiating power against traders (Ziegler et al, 2019), yet often times, unscrupulous traders who have more information use this advantage to buy from farmers at very low prices (Muto & Yamano, 2009); (Iraba, Venter & Tucker, 2010). A lack of information also means farms have to travel from market to market trying to find the best deal, yet increased transportation costs decrease the profitability once the product is sold (Muto & Yamano, 2009); (Iraba, Venter & Tucker, 2010). Knowing market prices does not automatically equate to improved prices in all instances, there are other factors at play as well in the market. It does, however, give the farmer an idea on where to set their price (Christensen et al, 2019).

Information is an important factor throughout the production stages in agriculture and its requirements differ depending on the type of agriculture practised and the stage of production. Agrarian farmers require information during the different stages of the agricultural process, from picking the right type of seed, land preparation and planting, growing, harvesting, packing and storing and finally marketing and selling (de Silva & Ratnadiwakara, 2010). The information needed at the different stages varies: at the beginning correct seed selection is important and as the process continues information on plant health, disease prevention and pesticide selection are required, farmers also need weather information and advice from extension workers (Gichamba, Waiganjo & Orwa, 2015); (Lwoga, 2010). Crop production and livestock production differ significantly and thus

require very contrasting sets of information. Pastoralists require information on best practices of livestock farming, inputs required to keep livestock, veterinary services, disease control, packaging and processing and also marketing and selling (Gichamba, Waiganjo & Orwa, 2015). All this information is required throughout the production process, and needs to be applied by the farmer as it affects whether a surplus will be produced to sell for an income. The information received by farmers is intended to supplement farmers' knowledge with expert advice, weather forecast, production techniques and other tips they would not normally know or have access to that can improve their production (Christensen et al, 2019).

The process of seeking information begins when the seeker identifies an information need; the recognition of this gap is followed by the seeker making a demand on a formal or informal information source to satisfy this need, resulting in failure or success of finding relevant information (Wilson, 1999). Finding information can be either a failure or success because not all available information will meet the needs of the farmer. Usefulness of information is often dependant on characteristics such as understandability, accuracy, contextualisation, relevance, accessibility, accuracy and timeliness (Muriithi, Bett & Ogaleh, 2009); (Gichamba, Wagacha & Ochieng, 2017). Having a credible source of information is as crucial as having access to information. Government agencies, universities and other non-governmental agencies that are authorised to work with farmers can provide timely and credible information to farmers (Gichamba, Waiganjo & Orwa, 2015). In the absence of accredited information sources, farmers often turn to other farmers or family members or input dealers for information (Adamides & Stylianou, 2013). At times information is passed down within the farming communities through traditional knowledge sharing culture of the community or village (Oregila, 2013). Having quality information is important and so is the receiver's ability to consume that data (Zhang, Wang & Duan, 2016). An information seeker's level of education often determines how they will perceive the usefulness and usability of information. Farmers with high levels of education often find the information they access useful and can utilise it, the opposite is often the case for less-educated farmers (Mokotjo & Kalusopa, 2010). Farmers need to understand the information they receive for it to benefit them (Mtega, 2012).

A lot of institutions in African countries often lack systems to adequately disseminate information to farmers, thus denying them a wealth of helpful information (Christensen et al, 2019); (Zhang, Wang & Duan, 2016). Selecting the correct medium to disseminate information drastically decreases the cost of sourcing it (Tadesse & Bahiigwa, 2015). Several channels can be used to disseminate information to farmers: radio, print media, television, library, telecentres, mobile phone, internet and face-to-face communication. All the different media have the potential to communicate a message and the effectiveness of the communicated message depends on factors such as time, accuracy, relevance, context, availability, accessibility and reach. The most appropriate information dissemination medium is determined by the structure of the information, cost of disseminating information, farmers' capabilities, information consumption behaviour and the local context (Zhang, Wang & Duan, 2016). Rural residents' favour oral communication as the most accessible and cheapest information sources, and they access information through extension agents, other farmers, family members and other influential people in the village (Adamides & Stylianou, 2013); (Mtega, 2012); (Aker & Fafchamps, 2014). Although verbal information is favoured, it is subject to distortion and if communicated by one person, may have very limited reach (Mtega, 2012); (Mokotjo & Kalusopa, 2010).

Another favoured source of information is radio. Radio reaches a large number of people all at the same time, radio waves can be received even at the most remote areas and some radios can be carried around, making the information accessible from anywhere (Mokotjo & Kalusopa, 2010). The drawback with radio is that shows play at a certain time, and if missed, the farmer cannot access that information unless the show is later repeated (Mokotjo & Kalusopa, 2010). The high cost of setting up a broadcast station also makes radio inhibitive, requiring expensive equipment or high charges for radio shows (Tata & McNamara, 2016). Television has similar benefits to the radio, with the added benefit of visualising the information through video. The drawback is that TV requires electricity to work, which may not always be available in rural areas and the broadcast is also costly and does not always reach everyone (Tata & McNamara, 2016); (Mokotjo & Kalusopa, 2010). Computers have worked well in other countries but in developing countries with the challenges of electricity and the cost of computers, they become less effective when compared to the other mediums (Mokotjo & Kalusopa, 2010). Print media is another important information dissemination medium which offers a sense of permanence and accuracy and is relatively easy to mass-produce. Libraries and print media are almost complementary as libraries mainly contain printed media, but the drawback with libraries and print media is that information cannot be updated instantly and libraries are located in fixed locations (Mokotjo & Kalusopa, 2010).

Studies have shown the successful application of ICTs in agriculture and they have been seen to improve; farm practices, the identification of better markets, the management of threats of pests and diseases and the overall running of farms and farming activities (Dodo & Reith, 2015). ICTs are pivotal to improving agricultural production in rural areas as well as decreasing information asymmetries and improving record-keeping for analysis to improve decision-making (Maumbe & Okello, 2010). The benefits of using ICT in agriculture are not widely seen in developing countries as there are still many challenges that impede their adoption. Lack of infrastructure like electricity and internet connectivity makes it difficult to use a computer and reap the potential benefits the device offers.

Mobile phones have developed rapidly over the years and their adoption transcends that of other forms of ICTs. In developing countries, mobile phones are the most widely spread form of ICT and their use spreads to even the most remote areas (Furuholt & Matotay, 2011). Some mobile phones have converged other forms of ICTs like radio, internet, email, voice calls and others all within the same device, allowing it to offer a host of benefits and features. The varied features of mobile phones, their widespread availability and ease of access makes them a favoured choice for studies that seek to determine how their use in agriculture can benefit farmers.

2.4. Mobile Phones in Agriculture

The mobile phone is seen as a strategic tool that can reduce poverty and foster economic development in rural areas (Iraba, Venter & Tucker, 2010). Features of mobile phones make it possible for rural dwellers to overcome a lot of the constraints they face when navigating their way out of poverty. Mobile phones are ubiquitous in developing countries because they are the most available and affordable form of ICT, thus found even in the most remote rural areas (Butt, 2015); (Iraba, Venter & Tucker, 2010). Ownership and usage of mobile phones is widespread, transcending income, age and gender lines (Adamides & Stylianou, 2013). The popularity of mobile phones is also boosted by their relative ease of use and intuitive nature which allows users to perform a lot of the basic functions without ever reading the user manual (Furuholt & Matotay, 2011).

The development of telecommunications in developing countries has sparked the interests of researchers on the impact of telecommunications, particularly mobile phones, on agricultural markets (Muto & Yamano, 2009). One of the advantages of mobile phone communications is that it occurs over a radio spectrum, eliminating the need for physical wires to operate. This feature addresses the infrastructural barrier that prevents most farmers from utilizing ICTs (Maumbe & Okello, 2010); (Das, Basu & Goswami, 2012). The mobile phone is also powered using a battery, which allows for mobility and provides a sense of security since the user is constantly accessible through the device (Das, Basu & Goswami, 2012). Using a battery helps mobile phone users circumvent the lack of consistent electricity supply, a common problem in developing countries (Dodo & Reith, 2015). More so because, once the phone has a full charge, the device can be operated without the need for a constant electricity source. Also, the innovative prepaid packages offered by mobile phone operators in developing countries increases the affordability and access to mobile phones (Das, Basu & Goswami, 2012). This means even poor farmers can own and use mobile phones freely. Mobile phones also offer a host of ways to communicate information, the services include; Short Message Service (SMS), Interactive Voice Response (IVR), Unstructured Supplementary Service Data (USSD), Installable Mobile Applications, Emails and Web Sites (Gichamba, Waiganjo & Orwa, 2015). The various features and dynamism of mobile phones make them an ideal gadget for disseminating agricultural information to remote rural areas (Adamides & Stylianou, 2013).

The new flow of information through mobile phones has helped farmers and traders in several ways. Some of the commonly stated benefits farmers receive from using mobile phones include; timely market and pricing information, farming practice and technical information, reduced cost of doing business, ease of making and receiving payments, reduced transportation cost, access to distant markets and traders, enable faster responses to disasters and warning to weather risks (Ogbeide & Ele, 2015); (Muto & Yamano, 2009); (Muriithi, Bett & Ogaleh 2009). Mobile Phones can facilitate the flow of information between different entities, and the lack of information flow is often the major cause of market failures for subsistence farmers and rural markets (Okello et al, 2010); (Salia, Nsowah-Nuamah & Steel, 2011). If farmers get access to market prices on their phones, they no longer have to spend a lot of money travelling between markets trying to find a good price to sell their produce (Muto & Yamano, 2009). Farmers who sell perishable goods may decrease or reduce produce wastage by knowing the prices beforehand (Muto & Yamano, 2009); (Salia, Nsowah-Nuamah & Steel, 2011). Further, receiving farming techniques and other technical information ensures that the farmer knows when to perform certain tasks to ensure that productivity and produce is optimal, and mobile phones can help in this regard (de Silva & Ratnadiwakara, 2010); (Gichamba, Waiganjo & Orwa, 2015). Products like Mobile Money have made it easy to send and

receive money, removing all the barriers and requirements necessary to open a formal bank account. A user only needs to have a valid mobile number and a mobile phone to register for the service (Kirui, Okello, Nyikal & Njiraini, 2013); (Gichamba, Waiganjo & Orwa, 2015).

Mobile phones are beneficial to rural inhabitants on more than just a commercial level; owners of the phones can maintain a wider social circle, keeping in touch with family and friends (Tomitsch et al, 2010). Rural inhabitants are also able to react to shocks like the sudden sickness or death of a loved one a lot easier when they have access to mobile phones. Users can deal with shocks using the phone which saves the individual time and money that would have been associated with the shock, such as travelling (Tomitsch et al, 2010); (Diga, 2008). Mobile phone owners also expressed a sense of pride and a feeling of belonging because they owned a mobile phone (Tomitsch et al, 2010). While there are many positives gleaned from owning or having access to a mobile phone, there are also some negatives associated with it as well. Some families have shown willingness to sacrifice basic needs like food, improved water and sanitation and have opted to redirect their funds towards owning a mobile phone, putting ownership of a mobile phone over their wellbeing (Diga, 2008).

Even though the penetration of mobile phones is high in developing countries some people are still unable to fully benefit due to accessibility constraints or other individual hindrances. The first major challenge experienced affects women. A lot of African cultures are still very patriarchal and the male head of the household controls the phone. Women are given limited access to the phone which inhibits them from receiving the potential benefits of owning a mobile phone (Diga, 2008); (Gichamba, Waiganjo & Orwa, 2015). Usability and literacy are also a major barrier for some users who often find it difficult to read communications received via SMS (Ziegler et al, 2019). Meagre financial resources are also a major bearer to mobile phone ownership (Molony, 2008). Therefore, in designing a system that can provide farmers with information that can improve their agricultural production; we need to consider the potential benefits and barriers of mobile phone use. Mobile phones offer a lot of features that can be used to communicate information to farmers and selecting the appropriate feature is vital. We need to consider the cost of implementation, ease of use and function for the end-user, the content of the message and the target audience. All these considerations will also help determine the effectiveness of the communications and improve the farmers' access to information.

Studies show the almost indisputable benefits that mobile phones have brought to rural residents, affecting their ability to easily socialise and improving their livelihoods in certain instances. This section on mobile phones in agriculture has shown how the ease of communication made possible by mobile phones facilitates the flow of agricultural information to farmers, thus improving their agricultural production. Having access to credible and quality information is crucial for the farmers to make informed decisions, and the sources of credible information can be government agencies, universities and organisation authorised to work with farmers (Gichamba, Waiganjo & Orwa, 2015). A lot of past research has heavily focused on the farmers receiving the information and the medium of information dissemination like the mobile phone. Though these two areas are crucial, the agencies that provide farmers with information also benefit from farmers leveraging mobile phones in agriculture by changing how they can communicate information to farmers.

2.5. Design Science Research (DSR)

The fields of engineering, information systems and computer science have practiced design science for decades and the results have been the development of new algorithms, new data and file structures, new programming languages and much more (Iivari, 2007). DSR is not new to the field of information systems, but the field has mostly focused on a research paradigm that produces and publishes descriptive research borrowed from other fields such a social and natural sciences (Peffers et al, 2007). DSR, on the other hand, is more concerned with the activities that result in the construction and evaluation of a technology artefact that meets an organizational need as well as the development of the theories associated with the artefact development (Cole et al, 2005); (Hevner, 2007). Researchers need to consider the appropriate and effective production and consumption of knowledge from the inception of their research right through to the communication of the research results (Gregor & Hevner, 2013).

The debate of how a DSR contributes to knowledge has raged on for a very long time. More so because, researchers in the academic community accept a study that makes a distinct contribution to knowledge. The first instance of knowledge contribution in DSR can be done through theory development (Gregor & Hevner, 2013), and the knowledge contribution can either be a partial or incomplete theory or a generalisation in the form of a new design artefact (Gregor & Hevner, 2013). A theory is described as "an abstract entity, an intermeshed set of statements about relationships among constructs that aims to describe, explain, enhance understanding of, and, in some cases, predict the future" (Gregor & Hevner, 2013). A theory typically evolves from a novel artefact all the way through to a mature theory with a greater understanding as to when and why it works, this happens as the theory goes through stages of testing, alterations and refinements (Gregor & Hevner, 2013).

The second instance of knowledge contribution is through the development of an artefact, the artefact referring to a "thing that has, or can be transformed into, a material existence as an artificially made object (e.g., model, instantiation) or process (e.g., method, software)" (Gregor & Hevner, 2013). Some IT artefacts have a certain degree of abstraction but can be converted into material existence, for example, an algorithm being operationalised as software (Gregor & Hevner, 2013). The artefact on its own cannot be considered as knowledge contribution, meaning if a piece of software is the outcome of a DSR, the software on its own does not contribute to knowledge building. Knowledge is created when method descriptions, constructs, design principles and implicit technological rules can be extracted from the artefact that has been developed; this allows the abstraction to be tried in other unstudied scenarios. Apart from developing theories and creating artefacts, a DSR has to contribute by solving a real-world problem (Gregor & Hevner, 2013). Many methods can be followed when producing a DSR, examples can be found in (Hevner et al, 2004); (Peffer et al, 2008) as well as (Offermann et al, 2009). The listed examples are not an exhaustive list of methods but give a list of the methods that were considered for this paper.

Design Science has its roots in engineering which is fundamentally a problem-solving paradigm (Iivari, 2007); (Hevner et al, 2004). The primary goal is to develop an artefact which needs to rely on a kernel theory that is applied in the problem-solving efforts (Hevner et al, 2004). The goal of behavioural science is to enable researchers to understand an organisational phenomenon, and the construction of the IT artefact enables design science researchers to understand the problem addressed by the artefact (Hevner et al, 2004). One cannot develop an IT artefact in isolation of the

kernel theory. Hevner et al (2004) developed a frame that will help DSR practitioners produce research that produces acceptable knowledge in the research community.

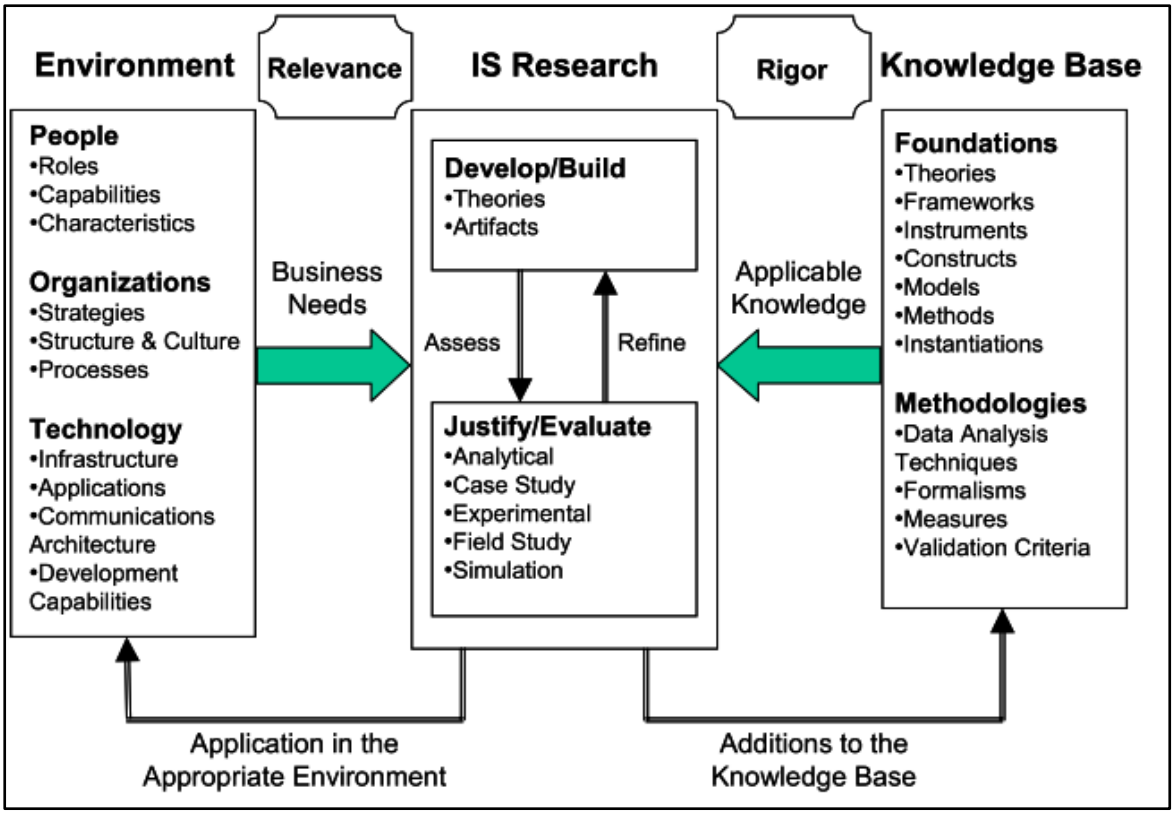

Figure 1: DSR Framework - (Hevner et al, 2004)

The framework presented by Hevner et al (2004) was developed to help researchers understand, execute and evaluate Information System (IS) research. The framework combines behavioural science which enables us to understand a phenomenon and design science to help in creating the artefact. As described by Hevner et al (2004), the environment describes the area of study where the problem of interest resides. The environment is made up of the people, organisation and technology. The business needs are assessed based on the business strategies, structures, culture and processes, perceived against the available infrastructure, applications, communications architecture and development capabilities. The study becomes relevant when the research activities that will be carried out address a real business need (Hevner et al, 2004).

IS research is conducted through two complementary research styles; behavioural science and design science. The behavioural science portion of the research aims to explain and predict phenomena related to the organisational business needs identified. The design science portion of the framework addresses the business need by developing an artefact that attempts to meet the identified business need. The two research methods cannot be separated because behavioural science addresses truth and design science addresses utility, and the assessment and refinement of both research types can result in the identification of weaknesses in either type (theory or artefact) and can lead to improvements (Hevner et al, 2004).

The final section of the framework is the knowledge base. This portion of the framework describes the work and the body of knowledge from the IS community. Work done by other authors in the field provides theories, frameworks, instruments, constructs, models, methods and instantiations

that would be relevant in the development of the IT artefact. Methodologies are used in the justifying and evaluating phase to provide guidelines for the research. The application of the elements in the knowledge base provides rigour to Design Science Research (Hevner et al, 2004).

The paper by Hevner et al (2004) also provides seven guidelines that can be used in IS research and help in achieving better understanding, executing and evaluating of IS research and results. The guidelines help in ensuring that the research process occurs in a manner that has all the scientific elements acceptable in all other research methods, that the research has rigour and is also communicated effectively to all manner of audiences (technology-oriented and management-oriented).

Guideline	Description
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Table 1: DSR Guidelines - (Hevner et al, 2004)

The framework by Hevner et al (2004) provides a guide that can be followed when doing design research. Other authors like Peffer et al (2008) have developed a model and Offermann et al (2009) have developed a process that outlines the steps that need to be taken when conducting the research. To clearly outline the distinction between a framework and a research process one may adopt the definition given in Offermann et al (2009), which states that a research process is applying a scientific method, which has clear steps to follow to the task of discovering a solution to a problem. A framework, on the other hand, is used to establish a research base and add to the available body of knowledge by doing a scientific investigation (Offermann et al, 2009).

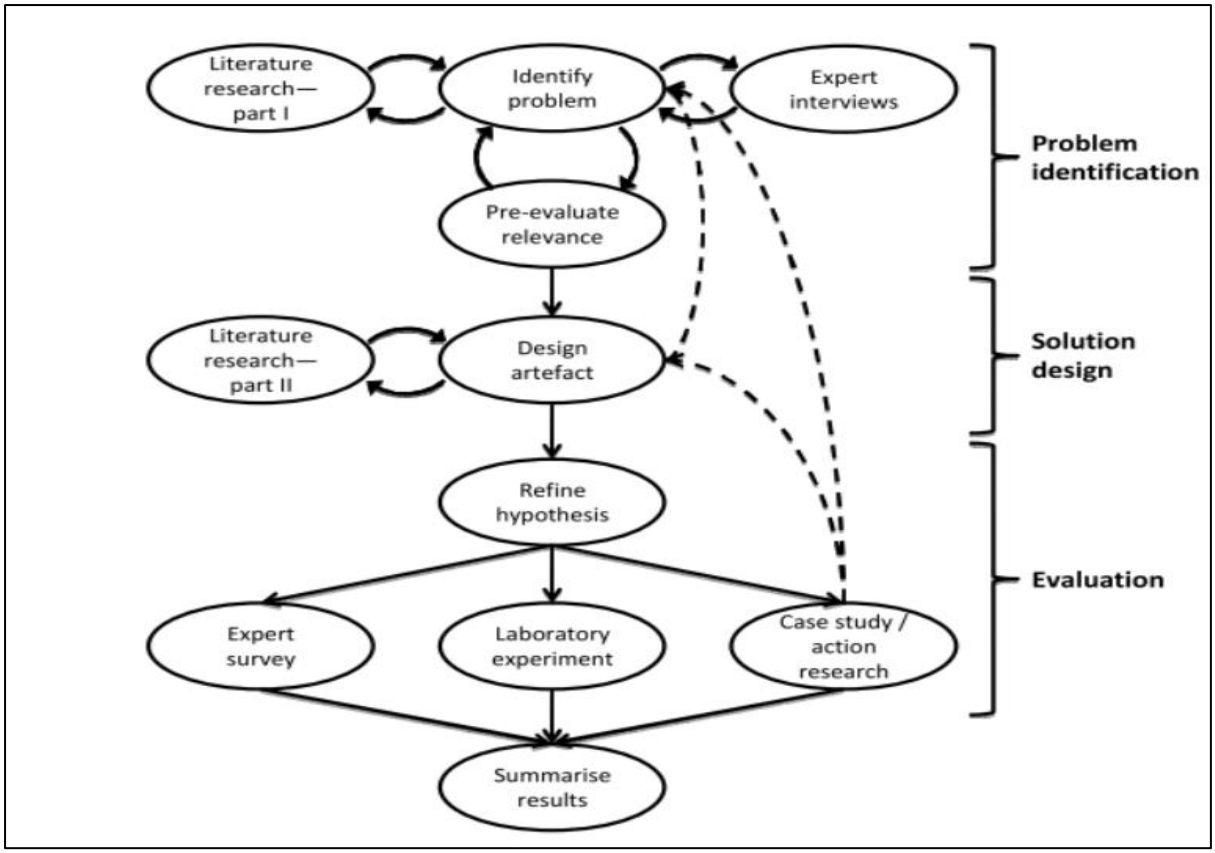

Figure 2: DSR Process - (Offermann et al, 2009)

The research process proposed by Offermann et al (2009) is developed from research methods from other IS research, and it is divided into 3 main phases: Problem Identification, Solution Design and Evaluation. Each phase contains steps that link one phase to the other and flow in a bidirectional manner, allowing a researcher to easily move from one stage to another (Offermann et al, 2009). Problem identification is the first part of the process and is divided into four steps namely, identify problem, literature research, expert interviews and pre-evaluate relevance. This first phase of the process identifies the problems through the adjoining steps and then evaluates the relevance of the problem identified (Offermann et al, 2009). The second phase of the process is the solution design phase; this phase is divided into two steps which include design artefact and literature research. In this phase, a solution is designed to solve the problem identified in the first step and done in the form of developing an artefact. This step ensures that rigour is applied by referencing available literature in the field (Offermann et al, 2009). The final phase of the research process is the evaluation stage and this is done once the developed artefact has reached a sufficient state. The evaluation phase is made up of five steps which are refined hypothesis, expert survey, laboratory experiment, case study/action research and summarising results. This final phase is where the developed artefact is analysed to determine if it solves the problem that has been identified, applying the adjoining steps shown in the process. The results of the whole research are then communicated in the form of a thesis or journal or conference article (Offermann et al, 2009).

The framework Hevner et al (2004) and the process Offermann et al (2009) discussed in this chapter have both been adopted in this study to answer the research problem. The framework gives guidance for the study to ensure that the artefact is scientifically studied and well communicated. The process gives the steps that are followed to produce the artefact from the problem identified. The steps in the process fit well in the adopted framework and both research framework and

process emphasize rigour and effective communication. Placing the steps of the process within the framework, we see the complementarity of the two.

The problem is identified in the environment portion of the framework, consisting of people, organisation and technology. Expert interviews and literature research is used to identify a problem in the process. The expert interviews are done with the people within the environment and the literature research involves reading studies of other authors and available organisational documentation, as well as reviewing what is available currently in the environment, like technology. The relevance of the problem is important in both the framework and the research process. The study becomes relevant if it solves a problem for the business or organisation. IS research is carried out to build an artefact and must be anchored by the kernel theory to ensure that the study occurs rigorously. The research process fits the IS research portion through solution design and the steps followed in the solution design are design artefact and literature search. The artefact is developed through studying literature and finding an anchoring theory, model or construct. Literature is also reviewed to see what other studies have found or done in an attempt to solve similar or related problems. The final stage of the framework is the knowledge base and is equivalent to the evaluation phase in the DSR process. The knowledge base refers to how the knowledge from the study is communicated; this is done through the evaluation phase in the research process. The first step is to verify that the designed artefact has addressed the problem, laboratory experiments, expert surveys; case studies can be conducted to test the artefact. The results of the study are then communicated through the summary of the results.

Given its research approach and execution, design science is pragmatic in nature (Hevner, 2007). DSR emphasises the creation of an artefact and contributing to the application environment. The artefact alone does not constitute a good Design Science Research, thus the importance of both the application (artefact) and the rigour applied (scientific) theory to define a good Design Science Research (Hevner, 2007). DSR solves a problem by applying scientific principles and in process produces a solution while also contributing to the overall body of knowledge.

Design Science Research like all other research types requires a sound ontological grounding (Iivari, 2007). Scholars of DSR offer a multilevel view of reality often subscribing to (Popper, 1978)'s 3 worlds (Iivari, 2007); (Gregor & Hevner, 2013). World 1 describes material nature, objectively looking at material things (Iivari, 2007); (Gregor & Hevner, 2013). World 2 describes mental states, consciousness and mental states. World 3 describes products, man-made entities or the products of human social action (Iivari, 2007), (Gregor & Hevner, 2013). A DSR can fall along the spectrum of the different worlds as an artefact can take any of the forms described in Table 2 by (Iivari, 2007). In the case of this research, the mobile phone is the object of study and can affect world 1 by changing the way farmers approach agriculture. World 2 comes into play in that using a mobile phone in agriculture gives farmers peace of mind, knowing they can receive the best market prices through their phone. World 3 can be affected by altering how parastatals or other organisations that work with farmers interact with farmers now that they have mobile phones. The two-pronged approach of DSR allows us to see a phenomenon in a multifaceted manner.

World	*Explanation*	*Research phenomena*	*Examples*
World 1:	Nature	IT artifacts + World 1	Evaluation of IT artifacts against natural phenomena
World 2:	Consciousness and mental states	IT artifacts + World 2	Evaluation of IT artifacts against perceptions, consciousness and mental states
World 3:	Institutions	IT artifacts + World 3 Institutions	Evaluation of organizational information systems
	Theories	IT artifacts + World 3 Theories	New types of theories made possible by IT artifacts
	Artifacts • IT artifacts • IT applications • meta IT artifacts	IT artifacts + World 3 Artifacts	Evaluation of the performance of artifacts comprising embedded computing

Table 2: Ontology for design science - (Iivari, 2007)

The main objective of design science is to develop an artefact; however, producing an artefact that excludes theories cannot produce any truth value (Iivari, 2007). If an instantiation of a theory produces a successful result consistently, then that action gives credibility and a level of truth to that theory (Iivari, 2007). Knowledge in DSR can be produced at different levels like conceptual knowledge, descriptive knowledge and prescriptive knowledge. The type of knowledge produced in DSR often depends on the artefact that is produced (Gregor & Hevner, 2013). Conceptual Knowledge is essentialist, identifying concepts and conceptual frameworks and their relationships, it offers no truth value but is useful when developing theories at the descriptive level. Descriptive Knowledge aims to describe, explain and give an understanding of how things are (Iivari, 2007); (Gregor & Hevner, 2013), while Prescriptive Knowledge describes the intended state of an object and how to achieve that intended state in an effective manner (Iivari, 2007); (Gregor & Hevner, 2013). All three knowledge types can be used to produce a type of knowledge in DSR (Iivari, 2007). The artefact that is developed in this study falls within the prescriptive knowledge creation. The developed artefact solves a specific problem and the proposed solution can be used to address other challenges in similar environments.

Type of knowledge	*Illustrations*
Conceptual knowledge (no truth value) • concepts, constructs • classifications, taxonomies, typologies, • conceptual frameworks	$c_1, c_2, \ldots c_n$, $C_1, C_2, \ldots C_n$ $U = C_1 \cup \ldots \cup C_n$; $C_i \cap C_j = \varnothing$, $i \neq j$ Systems concepts, ontologies, etc.
Descriptive knowledge (truth value) • observational facts • empirical regularities } causal laws • theories and hypotheses } (Niiniluoto 1993)	• X causes A in situation B • X tends to cause A in situation B with probability p
Prescriptive knowledge (no truth value) Design product knowledge Design process knowledge: Technological rules (Bunge 1967b) Technical norms (Niiniluoto 1993)	The artifact: • idea, concept, style • functionality, behaviour • architecture, structure • possible instantiation In order to achieve A • do (act_1, act_2, …, act_n) If you want A, and you believe that you are in a situation B, then • you should do X • it is rational for you to do X • it is profitable for you to do X

Table 3: Epistemology of design science - (Iivari, 2007)

2.6. Summary

This chapter looked at the literature that informs this study. The topics of interest were agriculture, information, mobile phone and their use in agriculture and design science. The topics discuss areas in the literature that help build the research questions and identify the gaps the study aims to fill. This chapter shows the importance of agriculture and how it is practised in developing countries. The chapter then goes on to link benefits of accessing information and how it affects agricultural production. Mobile phone in agriculture is another linking section, showing how agricultural information is disseminated through mobile phones. The final two sections discuss design science, the research type adopted by this study. The final topic in the chapter, design science discusses the framework and the process followed by the study to answer the research question.

3. Chapter Three – Theoretical Framework

3.1. Introduction

This chapter presents the theoretical framework adopted by this study as a guide to answering the research questions. The literature in this study looks at the model adopted Unified Theory of Acceptance and Use of Technology (UTAUT) and how it was developed and what elements make up the model. This chapter also looks at another model, Mobile Phone Technology Adoption Model (MOPTAM), presented as a model for mobile phone adoption.

3.2. Unified Theory of Acceptance and Use of Technology

A large number of models have been developed over the years to try and explain technology adoption, diffusion and acceptance. The Technology Acceptance Model (TAM) has been the model of choice for a lot of studies in the field of information systems and has resulted in a lot of publications (Liang, 2012). Over the years TAM has been modified and adapted to fit the cases studied, and the most successful modification of the TAM has been the Unified Theory of Acceptance and Use of Technology (UTAUT). UTAUT was developed based on the argument that there exists a lot of theories that share similar constructs and explain technology acceptance and use, thus, combining them and creating a unified model would provide a unified theoretical basis from which to facilitate research in the field of information systems (Williams et al, 2011). The TAM model is shown to be able to interpret user behaviour of systems at a rate of about 40%, while UTAUT on the other hand, can interpret user action up 70%, showing more effectiveness than the TAM model (Liang, 2012). Up until the development of the UTAUT model, the TAM had been the most popular model used to explain technology acceptance (Williams et al, 2011).

The UTAUT model, published in 2003, was developed through the review of eight prominent models in information technology acceptance research, the elements across the models were used to create and validate one unified model (Venkatesh et al, 2003). The different models whose elements formed the UTAUT model were the Theory of Reasoned Action (TRA), the Technology Acceptance Model (TAM), the Motivational Model (MM), the Theory of Planned Behaviour (TPB), a model combining the TAM and the TPB (C-TPB-TAM), the Model of PC Utilisation (MPCU), the Innovation Diffusion Theory (IDT) and Social Cognitive Theory (SCT) (Venkatesh et al, 2003), (Williams et al, 2011). From comparing and analysing the models, researchers extracted four constructs that played a significant role as a direct determinant of user acceptance and usage behaviour. The constructs are labelled as follows; Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI) and Facilitating Conditions (FC) (Venkatesh et al, 2003). The constructs are anchored by four moderators; Gender, Age, Experience, Voluntariness of Use, and these moderators influence each construct in a different way (Venkatesh et al, 2003).

In this section a breakdown of the different constructs is given without going into too much detail about the source that formed the construct. Performance Expectancy – This construct aims to measure how much a person believes the technology will assist them in doing their job, possibly by simplifying tasks or removing tedium from their work (Venkatesh et al, 2003). Gender and age play a moderating role in performance expectancy. There are instances where technology acceptance and adoption occur a lot more frequent with males than females not because of biological differences but because of social gender roles and expectations (Venkatesh et al, 2003). Effort Expectancy – is defined by the level of difficulty or relative ease of using the technology (Venkatesh et al, 2003), (Anderson & Schwager, 2014). This construct is moderated by gender, age and experience. Social

Influence – This construct measures the degree to which a potential adopter of technology perceives that an influential person or someone considered important, believes they should accept or adopt a technology (Venkatesh et al, 2003). Social influence is moderated by all the four moderating values, gender, age, experience, voluntariness of use. Facilitating Conditions – This construct measures the degree to which an individual believes that the resources (organisational and technical infrastructure) necessary to support user adoption and use of technology are available. This construct describes aspects of the organisational and technical structures designed to remove barriers to use (Venkatesh et al, 2003). This construct is moderated by age and experience. The first 3 constructs Performance Expectancy, Effort Expectancy and Social Influence all have a bearing on Behavioural Intention, which in turn will have a significant positive influence on Use Behaviour (technology usage) (Venkatesh et al, 2003).

Researchers have used the UTAUT in many different contexts; the model is used to predict behavioural intention to use technology, primarily in an organisational context (Venkatesh, Thong & Xu, 2012). The application of the model in different contexts, addition of new constructs to expand the scope of theoretical mechanisms and the inclusion of new predictors has expanded the model over the years (Venkatesh, Thong & Xu, 2012). The diagram below depicts the first instance of the UTAUT model as it first appeared in literature.

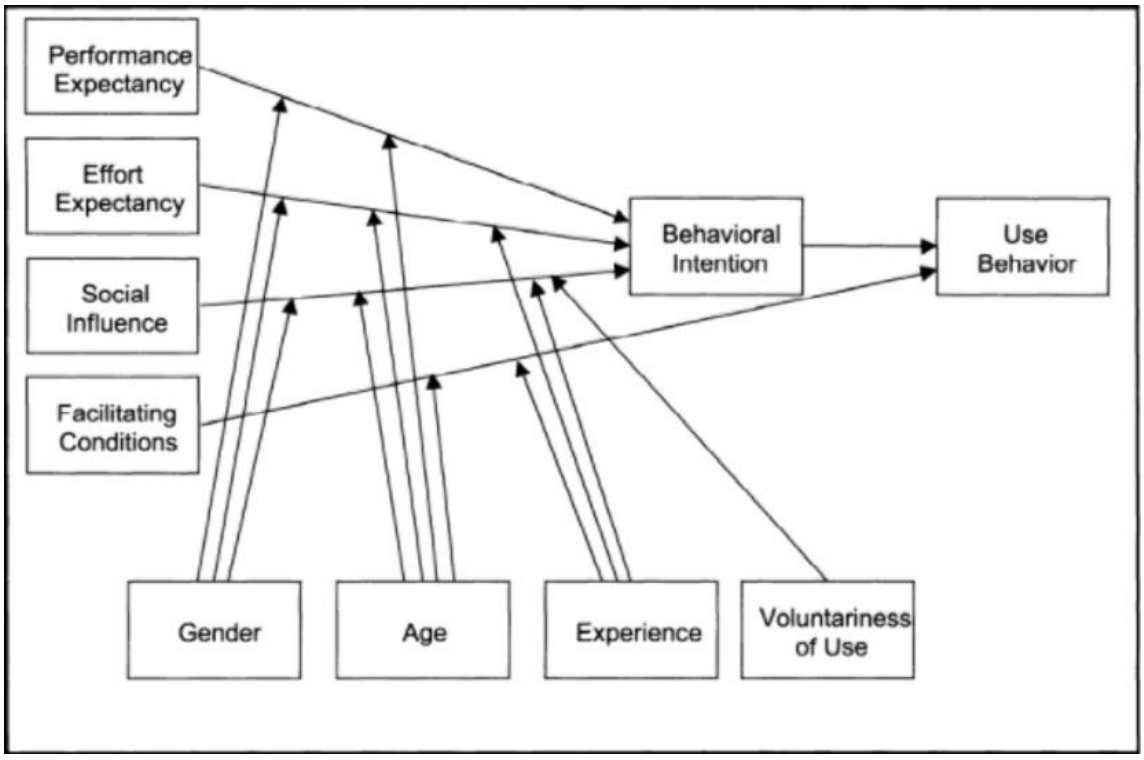

Figure 3: UTAUT Model - (Venkatesh et al, 2003).

The expansion of the UTAUT model has become commonplace in studies, and was necessitated by the different contexts of study. Findings of studies on mobile phone adoption in agriculture indicate that cost is a significant factor for customers when selecting to adopt and use mobile technology (Benard et al, 2016). Cost is the third most significant indicator for technology use and adoption, after ease of use and perceived usefulness. Customers are unlikely to elect to use a technology if the cost of doing so is excessively high (Benard et al, 2016). Other studies show that users are even

willing to forgo other essentials to be able to own and maintain a mobile phone but only to certain limits, cost is a big determining factor (Diga, 2008).

Benard et al, (2016) adopted the construct of affordability to fit the Ugandan context. Given that Uganda like most developing countries struggles with poverty, the cost of adopting and using technology became a major factor. Figure 4 illustrates the conceptual framework adopted in the study by (Benard et al, 2016).

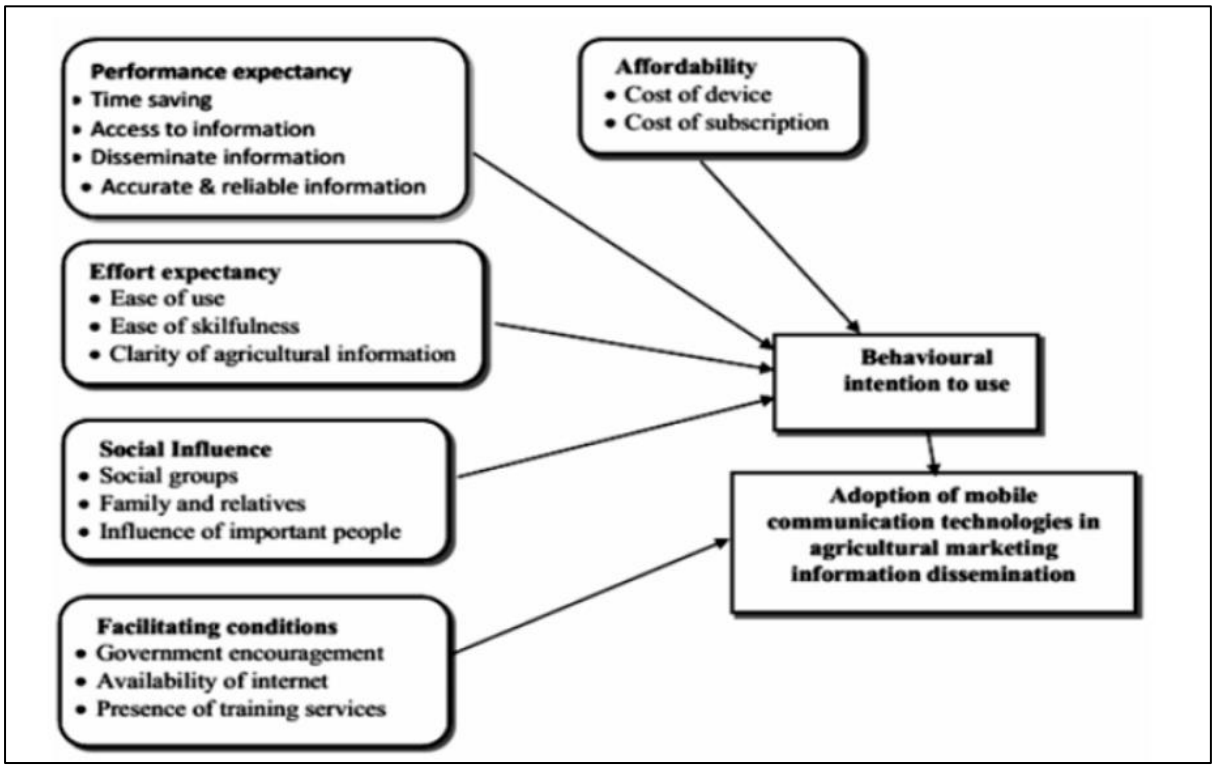

Figure 4: Conceptual Framework (Benard et al, 2016)

Cost is a big consideration for most consumers when deciding on technology adoption and use. The UTAUT2 model with 3 new added constructs (Hedonic Motivation, Price Value & Habit) shows that price is a big consideration for technology adoption and use for consumers (Venkatesh, Thong & Xu, 2012). The adoption and use of technology in an organisation also requires consideration of the price and the cost of adopting that technology, especially if the user will incur the cost of the adoption (Cohen, Bancilhon, Jones, 2013).

In this study, price needs to be a major consideration when developing the artefact because the target audience of the artefact are subsistence farmers who may not have the finances to adopt an expensive solution. Though the proposed model will be measuring adoption and use at the organisational level, price needs to be considered because of the targeted customer.

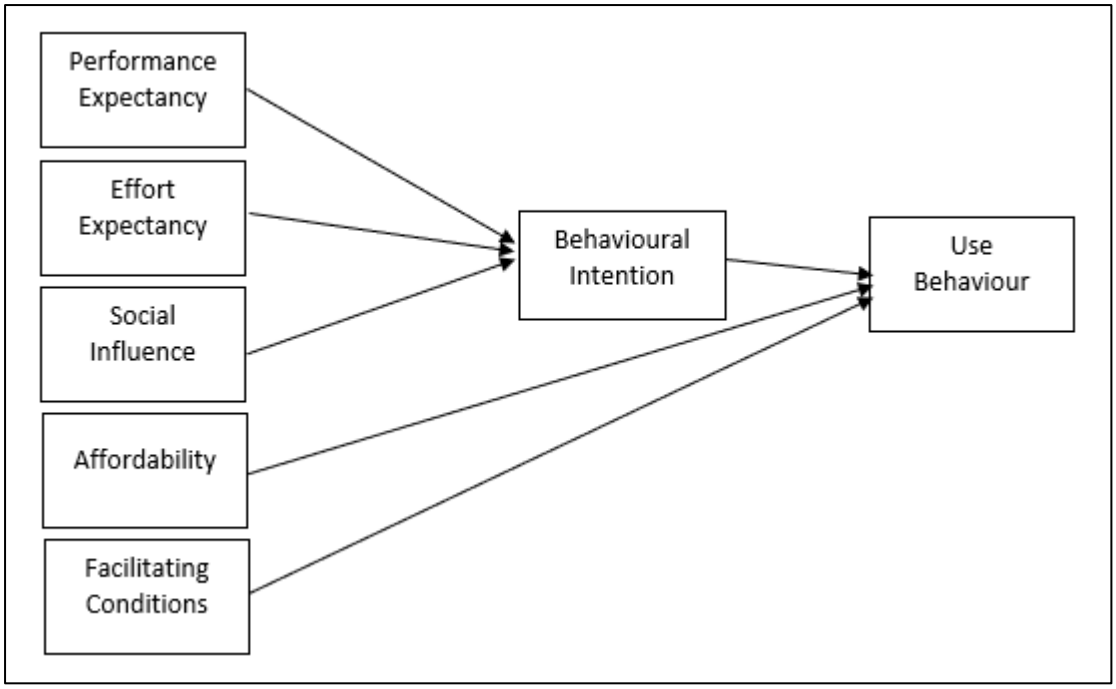

Figure 5: Conceptual Framework (Source: (Venkatesh et al, 2003), (Benard et al, 2016), (Cohen, Bancilhon, Jones, 2013))

The adopted conceptual framework is based on consideration from the 3 studies, (Venkatesh et al, 2003); (Benard et al, 2016) & (Cohen, Bancilhon, Jones, 2013). The four constructs, Performance Expectancy, Effort Expectancy, Social Influence, Affordability and Facilitating Conditions retain their original definitions from the UTAUT model (Venkatesh et al, 2003). Affordability as proposed by Benard et al (2016), influences behavioural intention, describing affordability from the consumer perspective. In a study by Cohen, Bancilhon, Jones (2013) the authors propose a model in which price value (cost) has a direct influence on use behaviour. A technology proposed for adoption and use should not only be productive but also provide a cost-effective solution (Cohen, Bancilhon, Jones, 2013).

This study proposes a new construct using the term Affordability from Benard et al (2016) because it not only describes affordability of the technology for the organisation but also the subsistence farmers affected. The study also follows the model used in Cohen, Bancilhon, Jones (2013) that indicates that affordability has a direct influence on Use Behaviour. The other constructs from the original UTAUT model (Venkatesh et al, 2003), remain unchanged and their definitions remain the same as well. The study does not apply the moderators of gender, age, experience and voluntariness of use in the adopted model because the employees that participated in the study are of similar age, educational background and experience. The influence to use technology is exerted from the managers, which leaves the employees with very little choice on whether or not to use a prescribed working tool. The proposed model adopted by this study is intended to explain technology adoption, particularly the design artefact from the study by the organisation supporting farmer development (ESWADE -SMLP). This model explains one side of the adoption of the artefact and a different model is proposed to explain technology adoption on the side of the farmers.

3.3. Mobile Phone Technology Adoption Model (MOPTAM)

As indicated earlier, mobile phones are incredibly popular worldwide, and compared to other technologies they have been widely accepted and have very high usage rates (van Biljon & Kotze, 2007); (Kwon & Chidambaram, 2000). The adoption and usage of mobile phones has attracted keen interest from scholars, as a result, has been studied in many fields, viz sociology, human-computer interaction and information systems (van Biljon & Kotze, 2007). The widespread use and adoption of mobile phones has seen scholars try to create a model that explains the adoption of mobile phones. The Mobile Phone Technology Adoption Model (MOPTAM) was developed from elements of two popular technology adoption and acceptance theories and models, TAM and the UTUAT. MOPTAM integrates determining factors from the TAM with mediating factors from UTAUT (van Biljon & Renaud, 2008).

The setup of conventional computing devices differs from mobile phones in many different ways; the number one fundamental difference is the mobility of phones. Mobile phones differ in four aspects, namely; Physical Context, Social Context, Mental Context and Technological Context (van Biljon & Kotze, 2007). The physical context refers to the physical attributes of the phone and the environment in which it is operated. Unlike traditional computing environments, where both the technology and the user are stationery and in a familiar location, mobile phones can be operated from anywhere (van Biljon & Kotze, 2007). A mobile phone has limited technical attributes (screen size, memory, storage space and computing power), compared to a standard computer (van Biljon & Kotze, 2007). The mobility of the device exposes the operator of the phone to various conditions that affect usage. The social context denotes the social interactions enabled by mobile phones. Users can interact with people who are geographically distant from them, allowing people to maintain strong relationships (Diga, 2008); (van Biljon & Kotze, 2007); (Tomitsch et al, 2010); (Kwon & Chidambaram, 2000). Mobile phones allow people to communicate with each other as a matter of choice rather than according to location (van Biljon & Kotze, 2007). The mobility also enables users to occupy two spaces at the same time, a physical one and a virtual one because of the conversation (van Biljon & Kotze, 2007). The mental context relates to the user's understanding of how to use the mobile device (van Biljon & Kotze, 2007). Since mobile phones are widely adopted, more than any other form ICT, they need to be intuitive and easy to use (Butt, 2015); (van Biljon & Kotze, 2007); (Iraba, Venter & Tucker,2010). The last context, technological context refers to all the supporting infrastructure and services, like networks, that allow mobile devices to operate (van Biljon & Kotze, 2007). Network coverage in developing countries does not always cover all the areas where the population resides. As such, lack of physical infrastructure is one of the major barriers to mobile phone use in developing countries (Maumbe & Okello, 2010); (van Biljon & Kotze, 2007); (Das, Basu & Goswami, 2012).

The four different contexts, physical, social, mental and technological, that appear in mobile computing do not necessarily feature in conventional computing, offering new challenges and opportunities when studying their adoption. Mobile phone adoption requires a model that will address the distinct features and characteristics that were not well considered when developing other technology adoption and acceptance models.

The MOPTAM, considers 3 models, Roger's Diffusion Model, TAM and UTAUT model, in the attempt to develop a new mobile phone adoption model (van Biljon & Kotze, 2007). The model takes elements from each of the theories to form the MOPTAM. The UTAUT model already considers and tests the Diffusion Model and TAM (Venkatesh et al, 2003), thus, the MOPTAM would almost seem

like a repetition of efforts made by other scholars. With the TAM and UTATUT having been developed to explain technology adoption, and mobile phones being a technology, it would seem appropriate for each of them to study mobile phone adoption. One of the challenges with using UTAUT and TAM in mobile phone adoption is that the two theories were developed and tested within the context of organisations, while mobile phones offer a completely different context and are used in numerous different environments making it difficult to account for some of the shortcomings in the models (van Biljon & Kotze, 2007).

On the other hand, the MOPTAM model was developed with the understanding that mobile phones and conventional computers have contrasting features, yet the available models do not adequately explain mobile phone adoption (van Biljon & Kotze, 2007). The MOPTAM features constructs and mediating factors gleaned from the TAM and UTAUT. Constructs from the TAM are; Perceived Usefulness, Perceived Ease of Use and Attitude, while constructs from UTAUT are; Social Influence and Facilitating Conditions. Behavioural Intention and Actual System Use appears in both models (TAM & UTAUT) since the UTAUT model was developed from studying the TAM and the last two constructs emerge from the TAM. The mediating factors Demographics Socio-Economic and Personal Factors form the remainder of the MOPTAM.

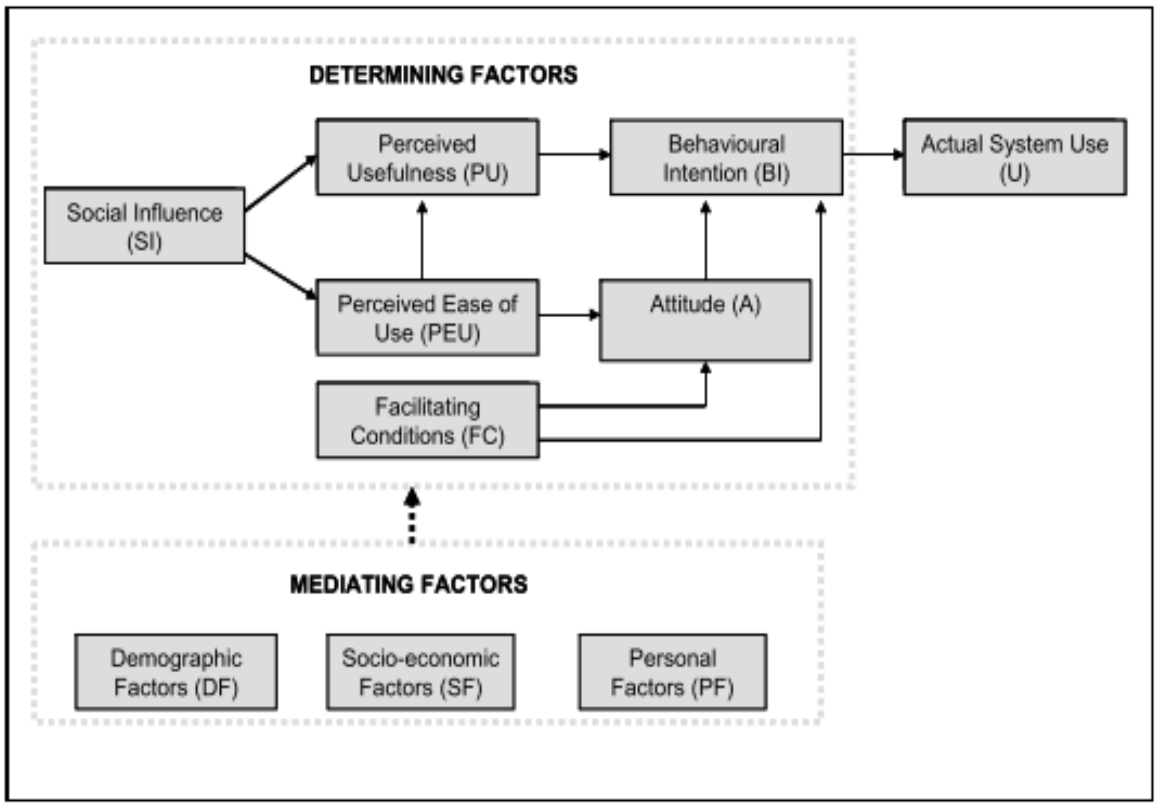

Figure 6: MOPTAM - (van Biljon & Kotze, 2007).

The definitions of the different constructs are similar to the original elements from where they were taken; slight changes and additions were made to fit the uniqueness of mobile phone adoption.

Social Influence in MOPTAM influences Perceived Usefulness and Perceived Ease of Use. This construct refers to the pressure an individual feel from other individuals or groups and their response to that pressure (van Biljon & Kotze, 2007). Mobile phone adoption can occur as a result of an individual feeling the need to fit in with other people who have also adopted the same technology (Tomitsch et al, 2010). Cultural elements also affect social influence. Some cultures are

still very patriarchal with men exerting a lot of control over a lot of decisions in the family. The men are the primary decision-makers in the family and decide if the technology is adopted and if adopted the men retain primary control of the device (Diga, 2008), (van Biljon & Kotze, 2007); (Gichamba, Waiganjo & Orwa, 2015). This construct influences Perceived Usefulness and Perceived Ease of Use. Social influence is a major factor that influences people's selection of a suitable mobile phone (van Biljon & Renaud, 2008).

Facilitating Conditions refer to infrastructure and other supporting conditions that make the mobile phone network possible. The combination of variables includes system service, system quality, packages offered by mobile network operators, cost of handset and service availability (van Biljon & Kotze, 2007). Services like prepaid mobile packages offered by a lot of mobile network operators in developing countries have made it possible for a much larger percentage of the population to afford using a mobile phone (Das, Basu & Goswami, 2012). Facilitating conditions look at the conditions that make it possible for users to adopt mobile use; this construct influences Attitude and Behavioural Intention (van Biljon & Kotze, 2007).

Perceived Usefulness retains the same description as in the original TAM, described as being the extent to which a user believes the use of the mobile phone will be beneficial to them (van Biljon & Kotze, 2007). Perceived Ease of Use is also described the same way as described in TAM, being, the extent to which the user believes using the mobile phone will be relatively free of effort (van Biljon & Kotze, 2007). Ease of use is one of the drivers for widespread mobile phone adoption, they can be used intuitively without ever reading the user manual (Furuholt & Matotay, 2011). The final two constructs of MOPTAM are Attitude and Behavioural Intention. Attitude describes the feelings towards engaging in target behaviour, the feeling can be either negative or positive. Behavioural Intention, on the other hand, describes the intention to engage in the behaviour to use a mobile phone, Behavioural Intention influences the actual use of a mobile phone (van Biljon & Kotze, 2007).

3.4. Discussion

IT artefacts differ in their design, functionality and role; this is also true for their diffusion and acceptance. It is the differences in the design, functionality and role that make it difficult to have one model or theory for IT acceptance and adoption that is valid for all IT application artefacts (Iivari, 2007). Both the UTAUT and the MOPTAM are good models for measuring a user's intention to use technology, their designs had different spheres of technology in mind and not one can be picked as a universal model for all studies. This study in particular needs to look at adoption from two different angels, even though there will be one artefact that is developed, the impact of the artefact developed is on the farmer who receives information and the parastatal that develops the content sent to farmers.

The different models are applied in this study to guide the development of the technology artefact. The models are used to ensure that the developed artefact matches the expectations of the users and also to ensure that there is a high degree of acceptance and use. The constructs of the different models help to determine the features that would address the identified problem. The use of two different models ensures that the developed artefact addresses the problem at the two different user levels. Some of the factors with great influence on the farmers using the developed artefact have very little bearing on the project staff. It is for this reason that two different models were used, to ensure that the factors determining the use of the technology are applicable to the differing user

demographics. User demographics like a farmer's age could affect the use of the artefact but from the perspective of the SMLP who are all a similar age (late 20s and early 30s) technology use comes with a lot less effort. The different models also necessitate considering that the types of interactions with the developed artefact will differ with the project staff and the farmers. It is, therefore, necessary to adopt models that address technology use and acceptance at the different levels of use at the level of user, and adopt a model that is suited for each type of user.

3.5. Summary

This chapter discussed the theoretical frameworks selected for use in this study, the UTAUT and the MOPTAM. The UTAUT model was selected to describe technology adoption at an organisational level. This chapter looks at the different models; studies that helped develop the model, and also describes the different elements that make up the model. An extra construct (Affordability) was added to the adopted UTAUT model to adapt it for the environment where the research was conducted. The second model that was adopted was the MOPTAM, and it was adopted to describe mobile phone adoption for the farmers. The chapter goes into detail on how the model was developed and also describes the constructs that make up the model. Two separate models were selected to cater for the different angles the research adopted. Each model is better able to describe certain elements of the research better than the other, adopting two models gives the study a well-rounded approach.

4. Chapter Four – Research Design

4.1. Introduction

This chapter describes the research methodology, research approach and research strategy employed in this study. The study adopted pragmatism as a research paradigm, the selected paradigm then influences the choice of qualitative research methodology and Design Science Research as a strategy. This chapter also presents data collection techniques, research instruments, data collection procedures and data analysis techniques. We cap off the chapter with a description of research ethics and timeframes.

4.2. Research Paradigm

A paradigm refers to a set of common beliefs, assumptions or concepts that relate to how a problem should be understood and addressed, a shared way of thinking (Oates, 2006); (Scotland, 2012). It describes how members of a certain community view a phenomenon, and details the research methodology employed to study that phenomena (Tuli, 2010). A paradigm consists of an ontology: the way we view reality, epistemology: the study of knowledge, axiology: how we believe it is obtained, and methods which are the steps we take to find out something (Scotland, 2012). A paradigm indicates the intent, motivation and expectations of the research. It is important to select a paradigm first because this becomes the basis for selecting the methodology, methods, literature and research design (Mackenzie & Knipe, 2006).

A researcher needs to indicate how they view reality and how they believe knowledge is gained, in this way they can select an appropriate paradigm to underpin their study. Even though the researcher may not be part of the study, their views on reality and knowledge affect the outcome of the study. A paradigm is distinctive due to its assumption about the nature of the physical and social reality, and the assumption about the nature of knowledge and how it is obtained; ontology and epistemology (Oates, 2006), (Scotland, 2012).

4.3. Ontology

Ontology describes the nature of the world and how we view it (Oates, 2006), it is the philosophy of reality, the study of being (Scotland, 2012); (Krauss, 2005). Ontology is related to the nature of reality (Tuli, 2010) and different ontologies exist in a scale between realism, which states that one reality exists and relativism which posits that many realities exist (Moon & Blackman, 2014).

1.0 ONTOLOGY: What exists in the human world that we can acquire knowledge about?				
← Realism: one reality exists →			← Relativism: multiple realities exist →	
1.1 Naïve realism Reality can be understood using *appropriate* methods	**1.2 Structural realism** Reality is *described* by scientific theory, but its underlying nature remains uncertain	**1.3 Critical realism** Reality captured by broad *critical* examination	**1.4 Bounded relativism** Mental constructions of reality are equal in space & time within boundaries (e.g., cultural, moral, cognitive)	**1.5 Relativism** Realities exist as multiple, intangible mental constructions; no reality beyond subjects

Table 4: Ontology - (Moon & Blackman, 2014)

The selection of a research paradigm (an ontology and epistemology) influences research activity and the methodology the study will follow. The selection of the paradigm also determines if the research is considered qualitative or quantitative (Tuli, 2010). This study adopts the pragmatic stance, unlike all the other paradigms, pragmatism does not commit to one system of philosophy or

reality, instead it adopts all necessary approaches to understand a research problem (Mackenzie & Knipe, 2006); (Moon & Blackman, 2014). Pragmatism considers the practical outcomes of research, like the artefact to be vital components of meaning and truth (Hevner, 2007).

4.4. Epistemology

Epistemology refers to the nature of knowledge, in particular, our perceptions on the acquisitions of knowledge (Hirschheim, 1985); (Oates, 2006). Epistemology aims to answer two basic questions; what is knowledge and how do we acquire valid knowledge (Hirschheim, 1985). Epistemology is not only concerned with what knowledge is and how it can be acquired, but also how knowledge can be communicated (Scotland, 2012).

2.0 EPISTEMOLOGY: How do we create knowledge?		
2.1 Objectivism Meaning exists within an object: an objective reality exists in an object independent of the subject	**2.2 Constructionism*** Meaning created from interplay between the subject & object: subject *constructs* reality of object	**2.3 Subjectivism** Meaning exists within the subject: subject imposes meaning on an object

Table 5: Epistemology - (Moon & Blackman, 2014)

Ontology and epistemology form the research paradigm, and influence the methodology which can be qualitative, quantitative or a combination of both methods (Mackenzie & Knipe, 2006). Knowing the paradigm or the philosophical stance of the research helps to give great meaning to the findings when the results of the study are communicated.

4.5. Research Method

The research methodology is the plan that lies behind the methods one selects to execute a study. It is concerned with the why, what, where, when and how data is collected and analysed and also how it will be communicated (Scotland, 2012), (Tuli, 2010). The research method is closely linked to the ontology and epistemology as one cannot determine a research method without first determining their view of known reality (ontology) and their view on the acquisition of knowledge (epistemology) (Tuli, 2010). This chapter describes the qualitative method adopted to conduct pragmatic research. The qualitative method is in line with the acceptable methodology used in pragmatic research. This chapter describes how a qualitative method was fitting and how it was used to conduct the phases of the design science process as well as data collection and analysis phases.

	Fundamental Beliefs			
	Ontology: the position on the nature of reality	**Epistemology**: the view on what constitutes acceptable knowledge	**Axiology**: the role of values in research and the researcher's stance	**Research Methodology**: the model behind the research process
Research Paradigm: Pragmatism	External, multiple, view chosen to best achieve an answer to the research question	Either or both observable phenomena and subjective meanings can provide acceptable knowledge dependent upon the research question. Focus on practical applied research, integrating different perspectives to help interpret the data	Value-bond and etic-emic Values play a large role in interpreting the results, the researcher adopting both objective and subjective points of view	Quantitative and qualitative (mixed or multimethod design)

Table 6: Pragmatic Research Paradigm adapted from - (Wahyuni, 2012)

4.5.1. Qualitative Research

A research paradigm of pragmatism can adopt either a qualitative or quantitative methodological approach exclusively or both of them simultaneously. For this study, a qualitative methodological approach was adopted. Qualitative research methods over the years have spiked in both adoption and use and have been used increasingly in more technology orientated fields like computer systems and information technology (Kaplan & Maxwell, 2005). Qualitative research aims to understand a phenomenon under study through the perspectives and behaviour of the people in the situation and the context which they act in (Kaplan & Maxwell, 2005). The qualitative research approach aims to explain a phenomenon through the use of qualitative data such as interviews, documents and participant observations (Meyers, 1997).

This study employed a qualitative approach because the development of the artefact will require more than just quantifiable data to meet the requirements of both the farmers and the ESWADE - SMLP. In line with the prescriptions of qualitative methodology, the research needs to fully understand the perceptions of both the farmer and ESWADE. The DSR framework, Hevner et al (2004), employed by this study indicates that the business need should be determined from the appropriate environment (people, organisation, technology), on the same token, qualitative research prescribes that the researcher studies a phenomenon by immersing themselves in the environment in which it occurs (Krauss, 2005). This makes the qualitative research method ideal for the research approach employed by this study. This study adopted qualitative data collection steps such as interviews, document review and match the design science research process (Offermann et al, 2009). Literature search and expert interviews make up the first step in the process of problem identification (Offermann et al, 2009). The qualitative approach adopted in this study fits well with the DSR framework and process and does a more effective job in leading the study into its' ultimate goal of artefact development and communication of the results.

4.5.2. Data Collection

This section describes data collection techniques that were employed in the study and the total populations and samples that were considered for the study. We also describe the sampling techniques and data collection methods in great detail.

4.5.2.1. Population ESWADE-SMLP Subject Matter Experts

The ESWADE-SMLP is broken down into four components, component 1 – chiefdom development planning, component 2 – infrastructure for soil and water conservation, component 3 – market-led agriculture, component 4 – implementation and administration. Component 3 is the front runner in farmer engagements and development and interacts the most with households in various communities. The ESWADE-SMLP project promotes value chains in livestock and crop production that farmers can choose to implement with support from the project. The supported value chains are; legumes, vegetables, fruits, indigenous chicken, goats and beekeeping. Farmers' engagements are done through 4 livestock officers reporting to a livestock coordinator and 4 sustainable agriculture officers reporting to a sustainable agriculture coordinator.

4.5.2.2. Sampling ESWADE -SMLP Subject Matter Experts

Purposeful sampling was selected when picking participants from ESWADE-SMLP to participate in the study. We engaged 4 participants, 2 from livestock production and 2 from crop production. The selection of participants from both agricultural production types ensures that we get a full picture from the different types of engagements they have with farmers, given the differences in their practices.

Sampling Technique	**Sampling Technique Category**	**Sampling Technique Description**
Purposive	Non-Probabilistic	The sample of participants is handpicked under the assumption that the selected participants will produce the most value for the study.

Table 7: Sampling Techniques Developed from work by (Oates, 2006)

Table 8 describes the total available staff in the ESWADE-SMLP project and the number of participants selected to participate in the study.

Project promoted value chains				
	Livestock Production		Crop Production	
	Goats	Apiculture	Legumes	Horticulture
Total Staff Number	2	2	2	2
Sampled Staff	1	1	1	1

Table 8: Number of participants after purposeful sampling

4.5.2.3. Interviews – ESWADE-SMLP Subject Matter Experts

In qualitative research, the interview is the most widely used research method (Schultze & Avital, 2011). The purpose of the interview is to clarify and understand how people's experiences influence their interpretation of the phenomenon under study. (Schultze & Avital, 2011); (Opdenakker, 2006). The interview differs from other research approaches by engaging directly with research participants in a conversation to gather contextual accounts of the phenomena studied, their experiences and how they interpret it (Schultze & Avital, 2011). Interviews need to generate rich data to be able to provide insight into people's lives. Rich data considers not just physical and social context but also the interviewees' intention (Schultze & Avital, 2011). Interviews can be done through face-to-face interviews, telephone interviews, emailed interviews or instant messaging (Opdenakker, 2006).

The different interviewing methods may be advantageous or disadvantageous, depending on the information being collected; the research determines the most appropriate interviewing method and how it will affect the quality of the study. For this study, we opted to use emailed interviews to obtain information from the subject matter experts (SMEs). We selected this type of interviews mainly because it was difficult to schedule face-to-face interviews due to the SMEs busy schedule. Opdenakker (2006) lists situations in which researchers may use email interviews to collect information. The use of email interviews is an acceptable form of data collection when:

i. Social cues of the interviewee do not form an imperative information source for the interviewer.
ii. When the research is restricted by budget and time constraints.
iii. There is no need to standardise the interview situation.
iv. Both the interviewer and the participant (the person being interviewed) are competent enough in typing and using a computer
v. The interviewee must take their time to respond to the interview questions.

Schedule clashes with the SMEs made it difficult to conduct face-to-face interviews. Also, the interview question did not gain much-added information from social cues, thus face-to-face interviews were not of added benefit to the study. We sent emails to the SMEs work account and they accessed them through laptops provided by the organisation. The emails were sent in English, a language all SMEs were proficient in and would be able to understand and respond to. The selected email interview method was sufficient for this study as it met the criteria described by Opdenakker (2006) of what makes the selected interview method acceptable.

4.5.2.4. Data Analysis – SMLP Subject Matter Experts

Qualitative data analysis includes data types like data from interviews, company documentation and other non-numeric data (Oates, 2006). Data is analysed to understand or interpret data that is collected and answer the research question (Kaplan & Maxwell, 2005). The first step of conducting a qualitative data analysis is data preparation, whereby audio recordings are transcribed and field notes and other relevant documentation is prepared to begin the analysis (Oates, 2006); (Kaplan & Maxwell, 2005). The researcher then reads through the text to gain an overall view of the data and determine if any themes or categories can be extracted from the data (Oates, 2006). Qualitative data can be analysed through various techniques such as "coding and contextual and narrative analysis" (Kaplan & Maxwell, 2005), and these techniques can be used in isolation of each other or together in order to identify themes and categories in the data. Codes are developed from the analysed text to gain insight of the results being produced by the study and facilitate comparison

and the development of a theory. This process is called the inductive approach, where categories and codes are observed through the data being analysed (Oates, 2006); (Kaplan & Maxwell, 2005). The modes of analysing qualitative research can be placed into two categories; hermeneutics and semiotics (Meyers, 1997). Hermeneutics aims to understand the meaning of a body of text which can be in the form of company documents, transcribed interviews and other relevant notes (Meyers, 1997), while semiotics deduce meaning from signs and symbols in the text by assigning them categories that represent elements of a theory being tested (Meyers, 1997).

Following research recommendations and good practice, we analysed and coded the responses from the emails sent to the SMEs. The themes extracted from the responses were later applied in the design of the artefact. The data collection method limited the types of analysis that could be performed. For instance, since the interview questions were emailed to the respondents, no observations could be made during the interview process. The responses from the emails were analysed to gain insight from the data, and were coded using NVivo, a qualitative data analysis software package, to be able to perform theme analysis. Other documentation that was analysed was the pamphlets sent to farmers and other project documentation that would help in understanding the interactions between the SMEs and the subsistence farmers. The analysis of the documentation was also coded and themes extracted to help in the development of the artefact.

Qualitative research needs to consistently produce valid results for any of the policies, suggestions, predictions and recommendations based on these results can be relied on (Maxwell, 1992). There are five types of validity identified in qualitative research; descriptive validity, interpretive validity, theoretical validity, generalizability and evaluative validity (Maxwell, 1992), (Hannes, Lockwood and Pearson, 2010).

The different types of qualitative research validities are described as follows:

i. Descriptive validity refers to the reporting of facts. Data is collected and used to gauge the accuracy of reporting on a specific phenomenon, no interpretation is done on this type of validity (Maxwell, 1992), (Hannes, Lockwood and Pearson, 2010).
ii. Interpretive validity is not solely concerned with providing an accurate description of facts but places focus of the meaning derived from behaviours, settings, events and the people engaged in and with them (Maxwell, 1992), (Hannes, Lockwood and Pearson, 2010).
iii. Theoretical validity aims to gain a better understanding of a research phenomenon, how it manifests itself and why it manifests in order to develop a theory behind the phenomenon (Maxwell, 1992), (Hannes, Lockwood and Pearson, 2010).
iv. Generalizability refers to the degree to which one studied individual or group can be extended to others or settings that are not under direct study. Generalizability is often a theory that can be used to make sense of other similar individuals or groups (Maxwell, 1992), (Hannes, Lockwood and Pearson, 2010).
v. Evaluative validity refers to the degree of legitimacy of a phenomenon under study, and involves the application of a framework to evaluate the phenomenon (Maxwell, 1992), (Hannes, Lockwood and Pearson, 2010).

The validity of this study leans more towards descriptive validity rather than any of the other described types. This study set out to address a problem and describe the steps taken to solve the problem. Descriptive knowledge is also one of the recognised knowledge contributions in design science research (Iivari, 2007). The artefact that is developed and the process followed to create the developed artefact will become the descriptive validity and knowledge of this study.

4.5.2.5. Population - Subsistence Farmers

According to the inception report for ESWADE-SMLP, the project development area has about 15 300 households with an average of 5 members per household. The population of the project development area is about 80 900 persons with 52% female and 48% males (SMLP Socio-Economic Survey, 2018)

Data about farmers in ESWADE-SMLP project development area were made available by the project. The data contains demographics of farmers that have developed beyond food deficit to a point where they can potentially supply a market. The total number of farmers available through an excel sheet was 2883, the sheet contained information with farmer's first name and last name, sex, value chain they participate in (Goats, Indigenous Chickens, Horticulture & Apiculture), age group (18 to 35, 36 to 60, above 60), location (Region, Inkhundla, Chiefdom and Section) and contact number. After filtering out farmers with mobile numbers and farmers not categorised in one of the age groups, the remaining number of available farmers was broken down as follows:

Age Group / **Sex**	**18 – 35**	**36 - 60**	**60 +**	**Total**
Male	155	126	24	*305*
Female	258	274	44	*576*
	413	*400*	*68*	*881*

Table 9: Number of farmers available after filtering list

4.5.2.6. Sampling - Subsistence Farmers

When targeting to describe a shared perception, belief or behaviour among a target group that has a lot of similarities and a sample size of twelve is likely to be sufficient in most studies (Guest, Bunce & Johnson, 2006). The subsistence farmers in this study share a lot of similarities: they all participate in one of the five promoted values chains (Goats, Indigenous Chickens, Legumes, Horticulture and Apiculture), all are supported by the same project in one way or the other and all are subsistence farmers. Also, the farmers are fairly similar to the targeted number of interviews, for this study the number was fifteen, a little over the recommended twelve for a group of similar characteristics. According to the MOPTAM model, demographic factors influence mobile phone adoption, thus to cater to those distinctions in the study, the participating farmers were selected to represent each age group and sex. The groups were not further separated by value chain because a lot of the farmers represented in the sample participated in one value chain often representing a crop and a livestock value chain.

The Sampling technique used to select farmers to participate in this study was Random Purposeful Sampling. Random Purposeful Sampling is a combination of random and purposive sampling employed when there is a very large pool of potential participants and there is no obvious reason to select one over the other (Sandelowski, 2000). Farmers were selected at random in each age group and ensuring to select a male and a female for balanced sex representation. The age groups with the much large numbers of farmers, also represented the majority of interviewees in the study. Table 10 shows the breakdown in numbers of the farmers that were requested to participate in the study.

Age Group / Sex	18 - 35	36 – 60	60 +	Total
Female	3	3	2	*9*
Male	3	2	2	*6*
	6	*5*	*4*	*15*

Table 10: Number of farmers requested to be part of the study

Farmer Demographics							
Participant	Sex	Age Group	Goats	Indigenous Chickens	Apiculture	Legumes	Horticulture
1	F	18-35					X
2	F	18-35		X	X	X	
3	F	18-35		X		X	
4	F	36-60	X	X			X
5	F	36-60		X			
6	F	36-60	X	X			
7	F	60		X	X	X	
8	F	60	X	X	X		
9	M	18-35		X			
10	M	18-35					X
11	M	18-35				X	
12	M	36-60	X	X			
13	M	36-60					X
14	M	60	X				
15	M	60	X	X	X		

Table 11: Interview Participants

4.5.2.7. Interviews – Subsistence Farmers

The interviewing method selected for the farmers was a telephone interview. The advantage of a telephone interview just like an email interview is the extended access to participants compared to face-to-face interviews. Telephone interviews are advantages in their wide geographical access, people from all over the globe can be reached given they have access to a telephone (Opdenakker, 2006). Another advantage of a telephone interview is that it reaches populations that are otherwise difficult to reach; this allows the researcher to reach or contact populations that might be difficult to interview using face-to-face interviews (Opdenakker, 2006). Telephone interviews also allow researchers access to participants in closed site access like prisons, access to dangerous or politically sensitive sites like warzones and enable interviewees to give sensitive accounts that they might not disclose in a face-to-face interview (Opdenakker, 2006). Interviews that do not have written responses need to be recorded, of course with permission of the respondent, and transcribed to be analysed. The researcher needs to take notes as well while the interview is in progress to add to the information being collected (Opdenakker, 2006). The disadvantage with telephone interviews, just like emailed interviews, is that social cues and body language cannot be observed (Opdenakker, 2006).

There are instances where telephone interviews are an appropriate method of data collection. Research by (Opdenakker, 2006) lists telephone interviews to be appropriate when:

i. Social cues are not an important source of information for the interviewer
ii. The study is constrained by budget, time and travel limitations.

iii. When looking to access people in distant locations or in areas where access is closed off or limited
iv. A situation in which the interview conducted does not need to be standardised.
v. A degree of anonymity is required.

With the size of the project development area of ESWADE-SMLP, it would prove difficult to reach the required number of farmers given the time and budget restrictions of the researcher. Telephone interviews allowed the study to reach a wide range of farmers selected at random. The interviews would not gain much-added insight from the social cues or body language of the farmers, thus the telephone interview proved sufficient for the study. The telephone interviews were conducted by first introducing the researcher and the research, the researcher would then request permission to record the rest of the interview before proceeding with asking the questions.

4.5.2.8. Data Analysis – Subsistence Farmers

Analysing the data from telephonic interviews required a different process than the process that was followed when analysing emailed interviews from subject matter experts. The telephonic interviews were conducted in Siswati (one of two official languages in Eswatini, the other being English) for ease of communication with the subsistence farmers. To prepare the data for analysis, the interview responses were translated and transcribed. The responses were analysed in English because that is the language in which the results of the study would be communicated in. The transcribed interviews were analysed to determine if any themes could be drawn from the data. The interviews were coded using NVIVO to better analyse the themes drawn.

4.6. Time Frame

The distinction between a longitudinal study and a cross-sectional study is the period taken to complete the study. A longitudinal study that occurs across different touchpoints over an extended period is typically observational by nature (Williams, 2007). A cross-sectional study is intended to look at and compare different population groups at a single point in time (Williams, 2007). Due to time constraints, this study adopted a cross-section approach.

4.7. Ethical Issues

There is increasing concern about ethical considerations of research, the rights and responsibilities of those involved in the research and what is considered as an acceptable research topic (Oates, 2006). The rights of people involved in the study were a major concern for this study, participants' rights include the right not to participate, the right to withdraw, the right to give informed consent, the right to anonymity and the right to confidentiality (Oates, 2006). The rights are also outlined in the ethical approval application from the University of Cape Town.

Before the interview could commence, the researcher explained the research to the participants and received verbal consent to continue with the interview. The researcher also requested permission to record the interview, and received verbal consent before asking any questions. The recordings were saved in a password protected cloud storage to ensure that recordings are in a safe location. The researcher also has the responsibility to be an ethical researcher, and being a responsible research entails refraining from unnecessarily intruding, behaving with integrity and avoiding plagiarism (Oates, 2006). The University of Cape Town guidelines and policies show very little tolerance for plagiarism, all work by other authors is referenced using the APA standard and the

paper is checked using plagiarism software (Turnitin) to ensure that no work from other authors is used without giving them due credit.

4.8. Chapter Summary

This chapter described the research paradigm that was adopted by this study, the research paradigm includes the ontology and epistemology of the study. The ontological and epistemological stance is what informed the qualitative research method employed by this study. The methods of data collection were broken down according to the dual view perspective of this study, giving detail on sampling, the methods selected for collecting data and the analysis and validity of the data. The second to last section is describing the time frame of the study and why a cross-sectional time frame was selected. The final section of the chapter describes the ethical consideration of the study and how they were handled.

5. Chapter Five – Problem Identification

5.1. Introduction

This chapter follows the problem identification process laid out in the DSR process by (Offermann et al, 2009) and the DSR framework proposed by (Hevner et al, 2004). The chapter presents findings from a study conducted with subject matter experts (SMEs) within the ESWADE-SMLP project and subsistence farmers in the ESWADE-SMLP development area. Both the SMEs and the subsistence farmers were interviewed to gain a better understanding of how the project disseminates information and how the farmers source and consume information. The data collection process and the methodology employed by this study are described in great detail in chapter four. The remainder of this chapter discusses the process followed in identifying the problem, highlighting the finds from the interviews conducted.

5.2. Application of the DSR Framework & Process

To apply a scientific approach to identifying the research problem the DSR framework and process are followed.

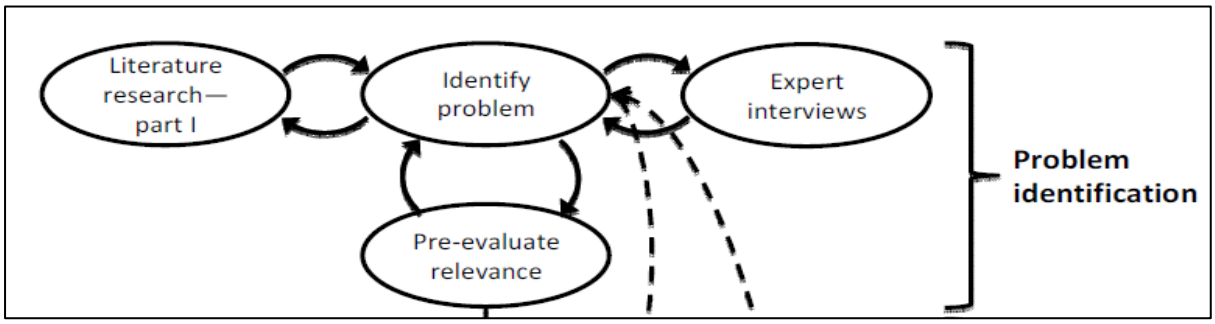

Figure 7: Part of Offermann et al, 2009 DSR Process – Problem Identification

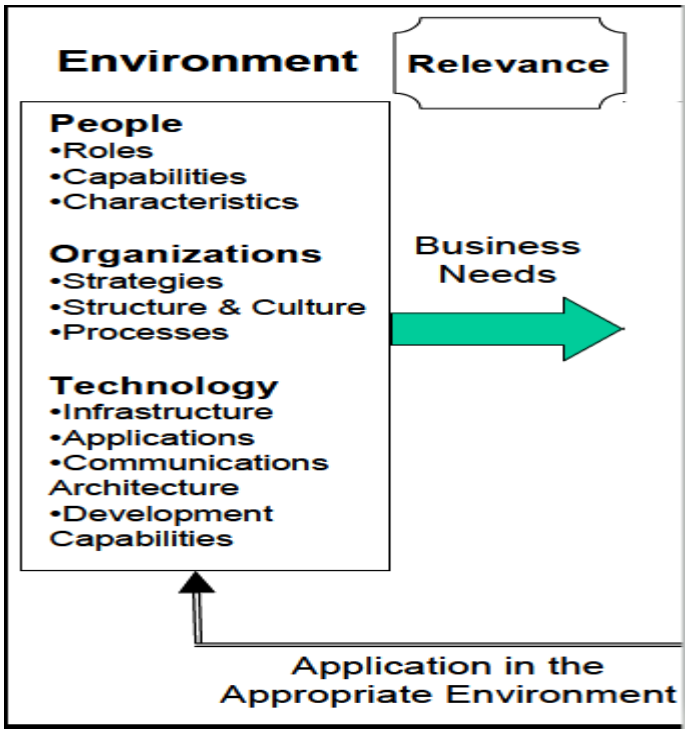

Figure 8: Part of (Hevner et al, 2004) DSR Framework – Problem Identification

In identifying the problem there is a need to understand the environment or problem space in which the phenomena reside, taking into consideration the people, organisation and the available technologies (Hevner et al, 2004). The first step of the study was to understand the environment and, in this study, the environment was looked at from the perspective of the farmer and the perspective of the ESWADE-SMLP, who would be disseminating information to the farmers.

5.2.1. Environment – DSR Framework

The key players identified in the studied environment are the farmers and the ESWADE-SMLP staff members, namely the subsistence agriculture officers and livestock officers. The project staff members execute the project objectives through farmer engagements and training. These trainings and engagements ensure that farmers gain access to information that is reliable and specific to their context and environment. Means of communication and engagement with farmers typically involve face-to-face communications, phone calls and pamphlet or training manual distributions. Such approaches have very limited reach and can be time consuming and expensive. The small number of project officers cannot adequately service the large population of farmers.

ESWADE supports the SMLP by providing technical staff and technology resources. The staff members use resources such as computers to create programs and training manuals for farmer education and training, servers to backup and save data collected from fieldwork and emails for internal and external communications. ESWADE also provides landline phones for staff members to make calls when they are in the office. The project staff also communicate with farmers using their cell phones. However, emails and phones are ineffective when communicating with farmers given the size of the target population and their access to certain types of technology.

Studying the environment, which is made up of people and their capabilities, roles and characteristics, helps us understand a problem within a specific setting. Studying the different actors in the environment helps us understand the role they play in the identified problem, while analysing the organisation, which is this case is the SMLP and ESWADE, makes us understand the context in which the different actors on the environment operate. The organisation encompasses strategies, structures, cultures and processes. The strategies, structures, cultures and processes look at the different ways the organisation operates which could affect the outcome of a problem that has been identified. The final element of the environment considers the technology in place within the environment. The technology helps to determine the advantages and the limitations within an environment and this could affect the type of artefact that is developed to address the problem identified.

Once the dynamics of the environment are understood through utilising the DSR framework, elements from the DSR problem identification process are applied to identify the research problem under study. The problem identification process from the DSR process is described next.

5.2.2. Problem Identification – DSR Process

5.2.2.1. Literature research

The DSR process proposes two steps in problem identification, literature search and expert interviews. The study interviewed farmers and SMLP project staff to determine the research problem.

The first step to identifying a problem is a literature search, literature on agriculture and development in developing countries is widely available. The literature review in chapter 2 discusses in detail the studies that were reviewed and how they informed this paper. The first point identified in the literature search is the high levels of poverty in the Kingdom of Eswatini. Over 70% of Eswatini's population lives in poverty ("Eswatini", 2019), (MOAC, 2005), (CSO, 2010), and rural residents constitute a majority of the poverty stricken. These statistics are disconcerting and require attention. According to literature, people remain impoverished because they lack the means, resources and information to convert assets they have into income-generating activities (Sife, Kiondo & Lyimo-Macha, 2010). Literature commonly suggests agriculture to be one the quickest means to escape poverty (Muriithi, Bett & Ogaleh 2009), (Muto & Yamano, 2009). Even though agriculture is commonly practised in developing countries, rural residents remain poor. The reasons behind high poverty rates amongst rural farmers are: ineffective labour-intensive agricultural practices such as using hand hoes and draught animals for land cultivation, disregard of technology and not utilising advanced agricultural techniques (Mabuza et al, 2013), (Muto & Yamano, 2009), (Okello, Kirui, Njiraini & Gitonga, 2012).

Farmers continue applying ineffective agricultural practices because they do not know better. If farmers had access to information, they would know what to do to address the challenges of extreme poverty (Zhang, Wang & Duan, 2016). The lack of access to information keeps farmers in a dire state of poverty and unable to produce enough to sell to a market (Okello, Al-Hassan, Okello, 2010). Also, the information needs to come from a reliable source for it to be trusted by farmers and effective. However, government agencies, organisations and institutions that have information often lack the resources necessary to easily disseminate information to the farmers timeously and effectively (Christensen et al, 2019), (Gichamba, Waiganjo & Orwa, 2015), (Christensen et al, 2019).

The literature reviewed reveals that poverty among farmers is not peculiar to Eswatini, rather it is common in other developing countries as well. The main problem identified in this study is that Eswatini struggles with high levels of poverty. Rural inhabitants engage in agriculture to produce food for their household consumption and a market, if they can produce a large enough harvest. Eswatini's farmers struggle to produce a bountiful harvest because they use old-fashioned agricultural practices which lock them in a cycle of poverty. The farmers do not change their practices because of ignorance; they lack information that can help them improve their agricultural practices. This explains the first perspective of the problem, farmers living in poverty are unable to change their practices because they do not have access to information that can help them.

The other side of the problem is from the perspective of the organisations who have the information that can help farmers. The literature shows that organisations like universities, governments and parastatals can form a reliable and trusted source of information. The challenge these institutions face is that they do not have the capabilities to share this information with the farmers. The means used have limited reach and are not very effective (Christensen et al, 2019); (Zhang, Wang & Duan, 2016). Eswatini faces similar challenges faced by other developing countries. The University of Eswatini, Luyengo Campus, focuses on agriculture and consumer sciences, the research and the findings from Luyengo campus seldom reaches the farmers. The scientific papers produced by

Luyengo scholars are not in a format and language that all farmers can understand. ESWADE, which was formed to execute the project from the Ministry of Agriculture, also has within it a wealth of information that could be beneficial to farmers, but the information is not adequately disseminated. ESWADE and the university are just two examples of institutions within the country that could form a reliable source of information for the farmers.

Use of literature search in the DSR process forms one part of the steps that are followed in problem identification. The next step is to talk to subject matter experts and the people experiencing the problem, in this case, the farmers. The information from the two sets of interviews with the subject matter experts and the farmers is discussed next.

5.2.2.2. Interviews

This section of the study describes the results of the interviews that were conducted with the farmers and ESWADE-SMLP staff. Chapter 4 of this study goes into more detail on how the data was collected and analysed. The choice of data collection method is described and why it was selected for this study. The interviews discussed in this section of the paper are about the DSR process and how they helped identify the problem.

i. ESWADE-SMLP Project staff

The primary objective of this section is to understand how the ESWADE-SMLP staff engage with farmers, how they provide farmers with information, what sort of information is currently available to the farmers and how farmers can access this information. The interviews focused on both crop and livestock production in order to get a full picture of the work done by the project.

The findings from the interviews with project staff show that the means of engagements with farmers are similar to those described in the literature. A lot of the engagements happen through trainings and demonstrations done when staff members visit the project development areas. These training sessions are used to communicate a range of information like new agricultural techniques, date and times of market days, advice and responses to the farmers' questions. Training materials and pamphlets are also distributed during trainings and meetings. Farmers also get information through extension officers and visiting animal health services. Other forms of farmer engagements take place through phone calls and in some instances through the mobile messaging service, WhatsApp.

Through the conducted interviews we can determine that a bulk of the communications happen through face-to-face engagements, in many different formats: meeting, training and demonstrations.

Table 12 shows some of the responses received from the interview questions about farmer engagements.

Participant	Comments on how they receive information
Officer (1)	"…information on upcoming events that are provided by the project through trainings, word-of-mouth, WhatsApp and phone calls, respectively. This information is passed on to farmer through trainings and when monitoring farmers during meetings"
Officer (2)	"…by extension officers, veterinary assistants and business development officers through trainings and monitoring visits."
Officer (3)	"One on one meetings with agriculture officers at RDAs"
Officer (4)	"…It is mainly disseminated by extension officers during the trainings..."

Table 12: Response from interviews on farmer engagements

Further analysis of the interviews shows that project officers would like to provide farmers with more information. The officers list information that could be useful to farmers, but is not easily disseminatable through the current information distribution means used. The information would reach a large enough audience when communicated through face-to-face communication. Table 13 shows some of the comments made about the information being sent to farmers.

Participant	Comments
Officer (1)	"...Weather forecasts, flowering dates of certain nectar-bearing trees and flowers (for Beekeepers), swarming times of bees."
Officer (2)	"...Information on diseases, innovations on production technologies and innovations on business practices"
Officer (3)	"…Soil analysis/examination and amendments recommendations which is currently lacking"
Officer (4)	"…Vaccination programmes Marketing information (Market contact details)."

Table 13: Response from interviews information that should be sent to farmers

The interviews show that farmers need to receive some information and ESWADE-SMLP has the information needed by the farmers. The challenge experienced is that the information distribution is limited and untimely.

ii. Subsistence Farmers

Farmers were interviewed to get information from them, determine from them what sort of information they need access to and how they are currently accessing information. The interviews, just like the literature and the information received from the project officers; show that there is a great need for information. The farmers normally source information from the place where they buy feed for their animals. The farmers indicated that is their primary source of advice and information. In addition, the farmers indicated that they need information on how to produce their product, how to determine if there is something wrong with the animal or plant health, and where to sell their produce once it is ready for market. Table 14 shows some of the responses received from the farmers.

Participant	Translated Comments
Farmer 9	"I haven't sold any chicken yet, but I have been wondering where I could get a market to sell these chickens…"
Farmer 12	"I would like to get information on the techniques I could use to keep indigenous chickens, an easy method that will quickly produce results…"
Farmer 15	"I normally just describe the conditions to the salesperson at the store and he is able to tell me what I should give them…"

Table 14: Table showing some responses from the farmers

5.2.2.3. Summary

Following the DSR framework and process, the study can determine the problem through understanding the context in which the problem occurs. The problem is better understood by doing a literature search and conducting interviews with SMLP project staff and subsistence farmers from the project development area. Literature search helps in understanding the problem from the perspective of other studies and contexts. A literature search also helps to determine the root cause and, in some cases, possible solutions. As part of determining the problem, interviews were conducted with both the SMLP project staff and the subsistence farmers. The interviews help to

contextualise the problem and also validate what was understood from the literature search. Once the problem has been determined, the next step is the design of a solution that can satisfy the needs of both stakeholders.

6. Chapter Six – Solution Design

6.1. Introduction

This chapter describes the steps taken in developing the design artefact. The study continues with the steps described in the DSR framework and process. The chapter also describes how the UTAUT and the MOPTAM models were applied to come up with the developed artefact.

6.2. Artefact development – System Requirements

The requirements for the design artefact were developed from the interviews with both the farmers and the project staff. The requirements are discussed in 3 separate sections to cover the different requirements for farmer types and the project staff.

i. Requirements for crop farmers

The first requirement by the crop farmers was the need to receive weather forecasts and also alerts when adverse weather is anticipated. This is also a requirement mentioned in the project documentation and by the sustainable agriculture officers. The farmers indicated that knowing the weather condition will help them know when to spray their crops or apply fertilizer. The farmers also want information on when is the most ideal time for them to plant certain crops, especially the crops promoted by the project. Farmers requested that the system advises them on the type of fertilizer they should apply to crops. This information is normally obtained from the nurseries or stores where they buy their farm supplies, as such, they cannot tell if they are receiving the best advice or just being sold a product.

The farmers also want to know what new techniques are available for them to use when cultivating their land. Farmers that have not received training from the project rely on techniques passed down to them by older farmers. Receiving occasional tips from the experts helps them produce a bountiful harvest. Crop farmers also requested information about markets, indicating that they normally sell to their neighbours because they do not know where to find markets. All the interviewed farmers indicated that they would prefer that the information be communicated in siSwati even though they can read English.

ii. Requirements for livestock farmers

The requirements for livestock farmers were more focused on animal health and being able to treat their livestock correctly in case of ill-health. Livestock farmers indicated that they describe the animal's symptoms to clerks at the feed store to obtain the correct treatment for their animals. Other farmers even try homemade remedies they have learnt from other farmers in their community. The farmers also want information on techniques that could help them produce a lot more livestock at a much quicker rate. These tips could help them increase their flocks and their potential to generate more income. The livestock farmers also indicated that they struggle to find markets for their products, thus end up selling at the farm gate.

iii. Requirements for project staff

The project staff want a system that will enable them to better engage with farmers they are supporting. The project hosts market days where the public is invited to come and purchase products produced by farmers. Communicating information about market days to farmers is a difficult process, and often some farmers do not get the message in time. Project staff members want to be able to broadcast a message to relevant farmers to come to market days and sell their wares. The project staff also need to conduct meetings or trainings with farmers and easily communicate messages to all famers. Other requirements by project staff are already covered by the needs of farmers for information. The project staff want to be able to give farmers tips and advice and reach many farmers at the same time. The SMLP also provides tractors services to farmers at a small cost and needs to be able to communicate the availability of this service to farmers and how they can obtain it.

In summary, the developed artefact needs to provide farmers with information easily and effectively. The artefact needs to reach a large population pool and deliver a message that is specific to the needs of the individual. The artefact needs to deliver a range of messages in a language that is understandable to the majority of the recipients. The artefact also needs to meet the needs of both the farmers and the project staff, each of the parties will uniquely interact with the system.

The identified requirements are passed through the adopted models to determine fit to the study and apply the rigour required in a Design Science Research. The DSR framework and process are closely followed to ensure that the study is conducted scientifically.

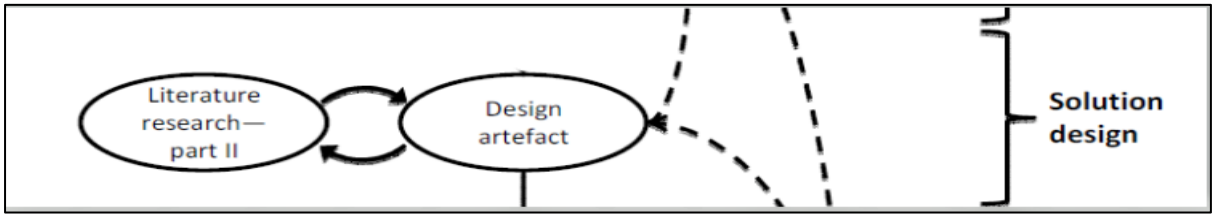

Figure 9: Part of Offermann et al, 2009 DSR Process – Solution Design

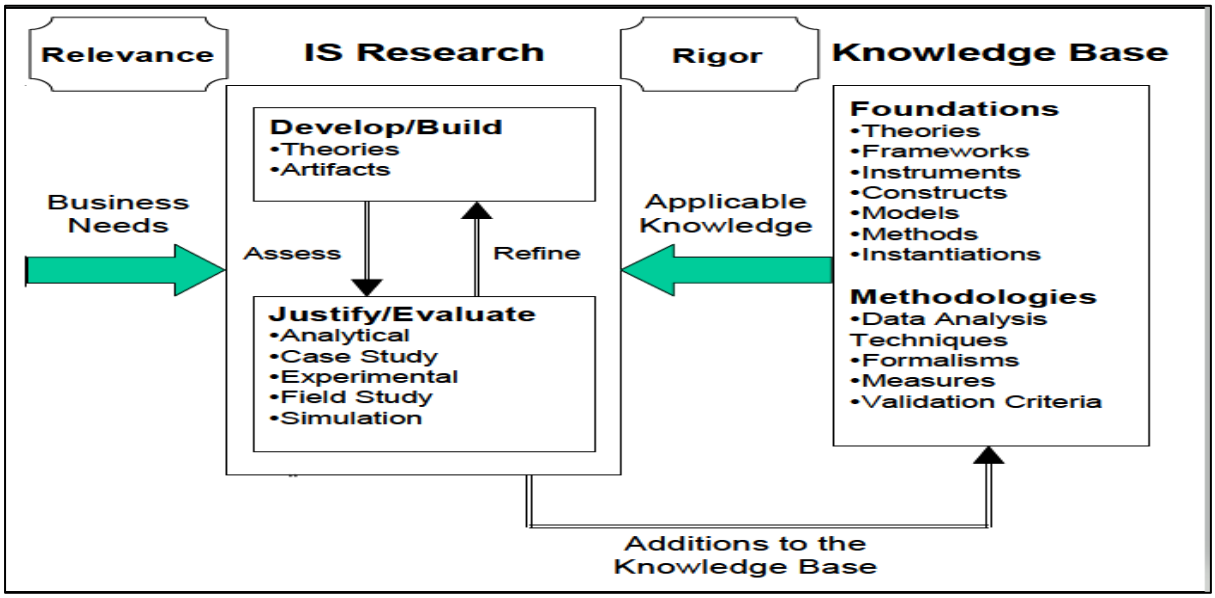

Figure 10: Part of Hevner et al, 2004 DSR Framework – Solution Design

The study applied the use of literature to determine the most suitable solution that could be applied to the problem that had been identified. The UTAUT and the MOPTAM are used to determine if the developed artefact addresses the identified problem and whether the proposed solution will become adopted as a solution.

i. Literature Research

The adoption of mobile technology in agriculture has been shown to improve the running of farmers and farming activities, decision making and overall farm management (Dodo & Reith, 2015), (Maumbe & Okello, 2010). The types of ICTs that can be adopted in developing countries are limited due to constraining conditions such as consistent power supply and other facilitating infrastructure required for their use (Maumbe & Okello, 2010); (Das, Basu & Goswami, 2012).

There is one type of ICT that has been widely adopted in developing countries, fast outpacing the adoption of any other ICT and adopted and used even in the most remote locations, the mobile phone (Furuholt & Matotay, 2011). The mobile phone becomes the chosen ICT to address the identified problem because of its wide availability and numerous options that can be applied to disseminate information i.e. Interactive Voice Response (IVR), Unstructured Supplementary Service Data (USSD) or Short Message Service (SMS) (Gichamba, Waiganjo & Orwa, 2015). In developing an agricultural platform, the target audience needs to know about the availability of the platform and its usefulness for them to use it (Gichamba, Wagacha & Ochieng, 2017). The chosen solution that would be developed in this study is an SMS application that would allow the project officer to send information to farmers.

ii. Application of the UTAUT model

The UTAUT model was applied to ensure that the adoption and use of the SMS based application could have a higher degree of certainty by addressing some of the aspects in the model that explain technology adoption. The UTAUT model was applied to explain technology adoption from the perspective of the organisation.

Performance Expectancy – The developed artefact needs to make it easier for the project staff to communicate with farmers and simplify the amount of effort exerted engaging with farmers. Currently, the staff members communicate through face-to-face engagements and distribution of printed materials in some instances. Table 13 gives an example of the response received from the project staff on engagements with farmers. The use of the SMS based messaging system will allow project staff to target the farmers they would like to communicate with and easily send a message to all of the farmers at the same time.

Effort Expectancy – The developed artefact needs to be easy to use for the user to perform the desired function without effort. The project staff need to be able to isolate the targeted group of farmers a message is intended for, and send it without exerting much effort. The current method of mobilising farmers to attend meetings and travelling to meet them is cumbersome. The developed artefact will make it easier to get information across farmers.

Social Influence – The developed artefact will be adopted by ESWADE as a working tool, employees will be required to use the messaging system as a way to perform their job. This means the influence will come from immediate managers and the project manager.

Affordability – This aspect talks to the affordability of the system. Affordability not only affects the organisation and the project officers but the farmers as well. Project officers often need to utilise their resources to call farmers, this can become expensive if not managed properly. The project also

needs to utilise a cost-effective artefact that will continue to function when the project ends and all resources are handed over to the Ministry of Agriculture. The affordability construct affects farmers in that if the cost of providing information is ever passed on to them, the cost should not be too expensive for them to adopt the service.

Facilitating Conditions - Facilitating conditions cover not only the resources required within the organisation, but also the availability of the farmers' resources to adopt the service. The artefact requires a database, servers and an active internet connection to be able to deliver the service. On the side of the farmers, they need a mobile phone and an active mobile service subscription to receive the messages. All of the stated conditions are available, meaning there are no facilitating conditions that could prevent the adoption of the artefact.

iii. Application of the MOPTAM model

The artefact being developed leverages mobile phone technology already widely used by the farmers. The MOPTAM model is used to predict the use of the SMS messaging system by the farmers.

Social Influence – The SMLP has a lot of influence on the farmers in the project development area, this rides on the good reputation of its parent organisation, ESWADE which is implementing the project. The influence of the project could encourage a lot of farmers to adopt the service.

Perceived Usefulness – The farmers were asked about their current source of information, and most indicated that they normally get their information from employees of local feed stores. All the interviewees expressed a need for information, and a simplified information delivery service would be useful to them.

Perceived Ease of Use – The farmers were asked to state how familiar they were with utilising their mobile phones, how easily they could find things like messages and make calls. The younger farmers said they are very familiar with their phones and can navigate very easily. Older farmers, on the other hand, indicated that if they are not able to find something like messages on their phone, they normally just ask children they live with to help. Notably, with this artefact, farmers will only receive messages, they won't have to do anything in terms of configurations or set up to access the service.

Facilitating Conditions – The only facilitating condition to receive information from the system is a working mobile number. The farmers indicated that they do not share the mobile phones they use and they always have access to it. The service is currently offered for free at the moment, the costs are all absorbed by the project. The service needs to be provided at a low cost if the current model is changed at a future date.

Attitude – Currently, there is a positive attitude and sentiment toward the organisation providing the service. The SMLP has a good reputation in the areas in which it supports farmers, this would have a great effect on whether the service is trusted and adopted.

6.3. Artefact development – First Iteration

After considering the literature and the needs of the SMLP and farmers an artefact that uses SMS to send messages to farmers was developed. From the requirements of both the farmers and project staff, it is clear that information still needs to be communicated. The literature shows that technology is an effective means to disseminate information and mobile phones are the favoured means in rural environments.

According to the requirements, the project staff needs to send different types of messages to farmers, the content could be market information, farming tips and other relevant information. The developed artefact captures the type of message sent to the farmers. The project staff also needs to target certain types of farmers, this requirement covers an individual farmer or a group of farmers. The developed artefact addresses this requirement by allowing the project staff members to enter the numbers manually or select a group of farmers from predefined filters. Since the artefact uses an already existing database with farmer demographics, it can filter the farmers according to the selected characteristic.

The developed artefact also needs to allow project staff to send different types of content and send it in siSwati as required by the farmers. The system allows project staff to type their message in either English or Siswati. The system is meant to ease the amount of effort required to send a message to an intended audience. Inputting the communication type is done through making a selection on a drop-down list. The project staff member then does the same thing when selecting a group to target with messages. The project staff can pick to target the following groups:

- All farmers in a certain Region, Inkhundla Chiefdom or Section (location-based filters)
- All farmers in certain Committees (In certain areas farmers are grouped to form committees)
- All farmers in a Farm Group (In certain areas farmers are grouped together to participate in a value chain e.g. farm chickens as a group)
- All farmers in a value chain (This is referred to as a Farm Business in the project and could be Horticulture, Apiculture, Legumes, Indigenous Chickens or Goats)

The developed artefact allows the project staff member to target one group at a time. Once a selection is made the system searches the database for farmers that meet the criteria and makes all the other drop-down lists inactive. The project staff member could also opt to enter the numbers manually, this option disables all the other filters and allows the user to type numbers individually.

The system uses a role-based authentication method meaning the project officer needs to log in with a username and password and also have the appropriate rights to be able to send messages to farmers. Once a user with the appropriate credentials and rights has completed the steps required to send a message, they press send to push the messages to the appropriate farmers. The messages are then saved in the database to keep a record of all the communication that happened between each farmer and the project officers. The servers then push the messages to a bulk SMS provider that sends the messages accordingly. Figure 11 shows the information flow in the system and Figure 12 shows how the different stakeholders interact with the system.

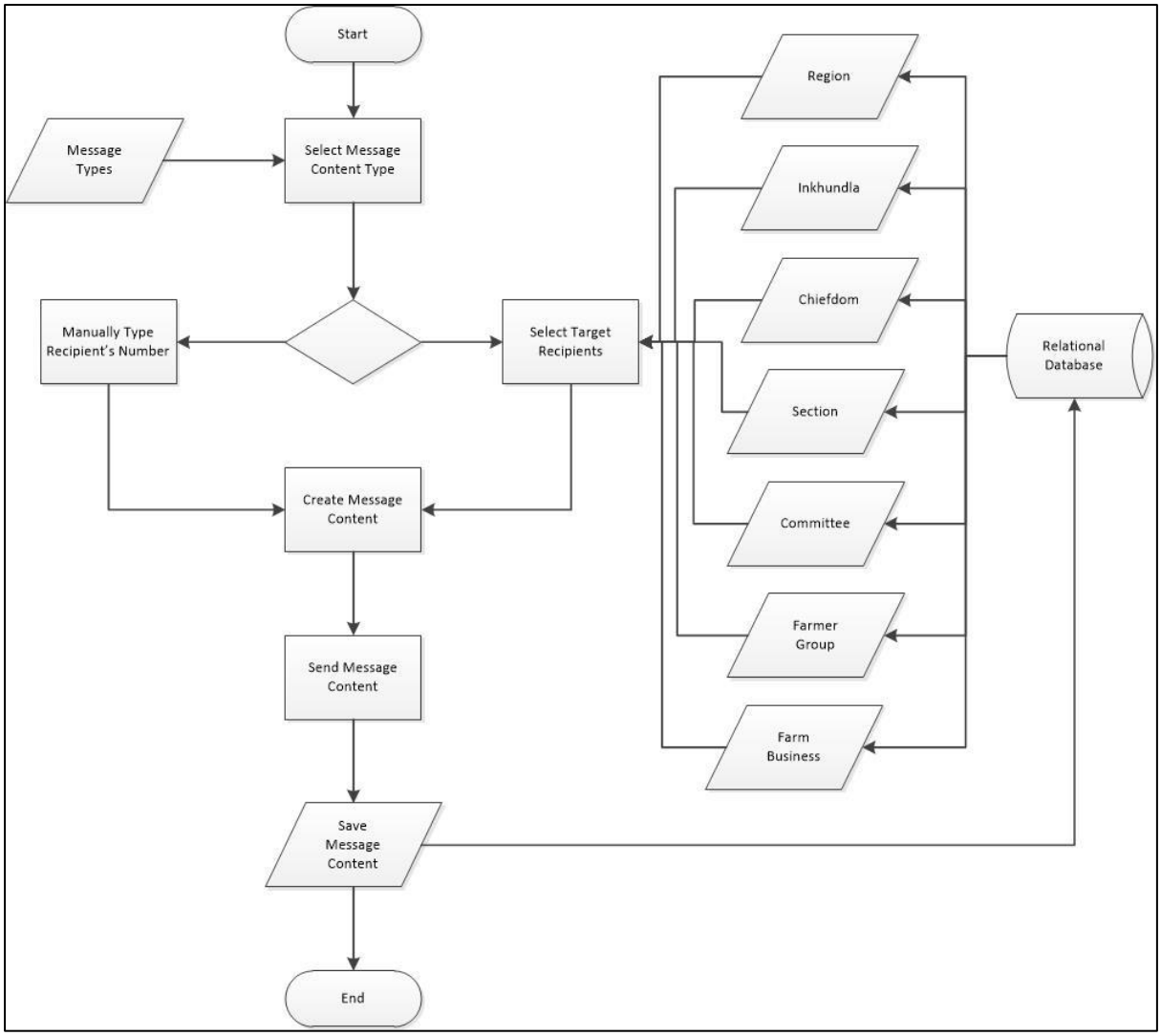

Figure 11: Flow Chart for SMS System – Iteration 1

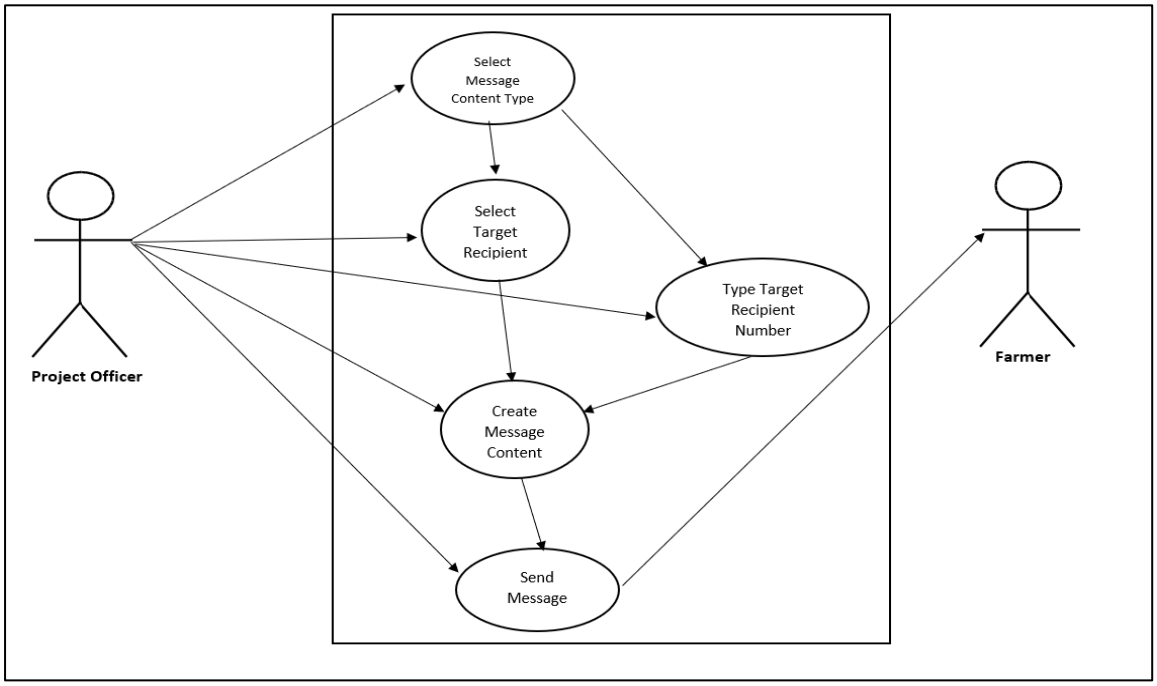

Figure 12: Use Case Model for SMS based messaging system – iteration one

6.4. Artefact development – First Iteration Evaluation

The system was evaluated on a technical level and this section discusses the constructs where the first iteration falls short to meet the desired result from both the perspective of the farmer and the project officer.

i. Technical Evaluation – Project Staff Members

Performance Expectancy – The system functioned as expected and was able to disseminate information to the farmers. The results of the evaluation of the first iteration revealed a gap in that the quality of messages sent to the farmers was not checked and signed off before they were sent. Also, project officers could send messages without restriction. The messages sent need to be verified and quality checked to ensure that the farmers receive quality information.

Facilitating Conditions – Testing and use of the system also revealed difficulty in sending messages when project officers are not on the organisation's network. ESWADE systems and servers are closed off from external access, this makes it challenging for project officers to send messages to farmers when they are out in the field. This could be resolved through the implementation of a VPN or firewall, but given the limited resources of the research, an alternative method had to be implemented.

ii. Technical Evaluation – Farmers

Attitude - The messages received by farmers came from a short code (33333). Thus, a lot of farmers did not bother reading the messages because they assumed that they were receiving spam or advertising. Thus, messages from the project were easily missed and farmers did not receive the information they need.

6.5. Artefact development – Second Iteration

The second iteration describes three areas that were not met by the development of the first iteration. The first iteration allowed the project officer to send information to farmers without verifying the content, this freedom could negatively affect the quality of the information. The second challenge that was not addressed is that users need to be in the office to be able to send a message, this is not always possible because the primary job of project officers is to be in the field engaging with farmers. Lastly, farmers ignored the messages because of the short code (33333) that was used by the system.

1. The first challenge was addressed by adding a further step to be taken before a message was sent to farmers. The project officer follows the same steps described in the first iteration and saves the message to be sent to farmers. The project officer's manager then logs onto the system to check the message and decides whether to approve or decline the message to be sent. The project manager has the option to update the content of the message and elect to approve it or just decline it. The system captures the original author of the message and the details of the manager if they elect to alter the contents of the message.

2. To allow the project officer to send messages to farmers even when out of the office, a queuing function was added to the second iteration. Instead of allowing the project officer to send the message immediately after typing out the content, the project officer has to select a time and date for when the message must be sent. The system will only send messages to farmers that have been approved and whose time and date has been reached. A function on the server checks if there are any messages on the system that have been approved and whose time and date for sending has been reached. The function on the server then triggers the system to send the messages to the farmers. This function runs between 5 a.m. and 8 p.m. as not to disturb farmers by sending messages at odd hours.

3. The system adopted a Sender ID option which allowed the messages that are sent to get delivered as ESWADE-SMLP in place of the short code 33333. When farmers received a message from a Sender ID they recognised, they did not immediately delete or ignore the message.

The shortfalls identified in the technical evaluation of the first iteration resulted in slight changes in the information flow and technical structure of the artefact. The second iteration needed a structural change in the database to add a step that allows a manager to approve a message before it is sent. The second iteration also added a step that allowed the user to queue their message to be sent at a later time or date. The added step required a function to be added to trigger the message to be sent once the set date and time was reached. The last change to the system was switching from a short code (33333) to a sender ID (ESWADE-SMLP). The last change was accompanied by farmer engagement by the project staff to let them know that they would receive messages from Sender ID (ESWADE-SMLP)

Figure 13 shows an updated use case model of how the user interacts with the system and Figure 14 illustrates how information flows given the changes made to the artefact.

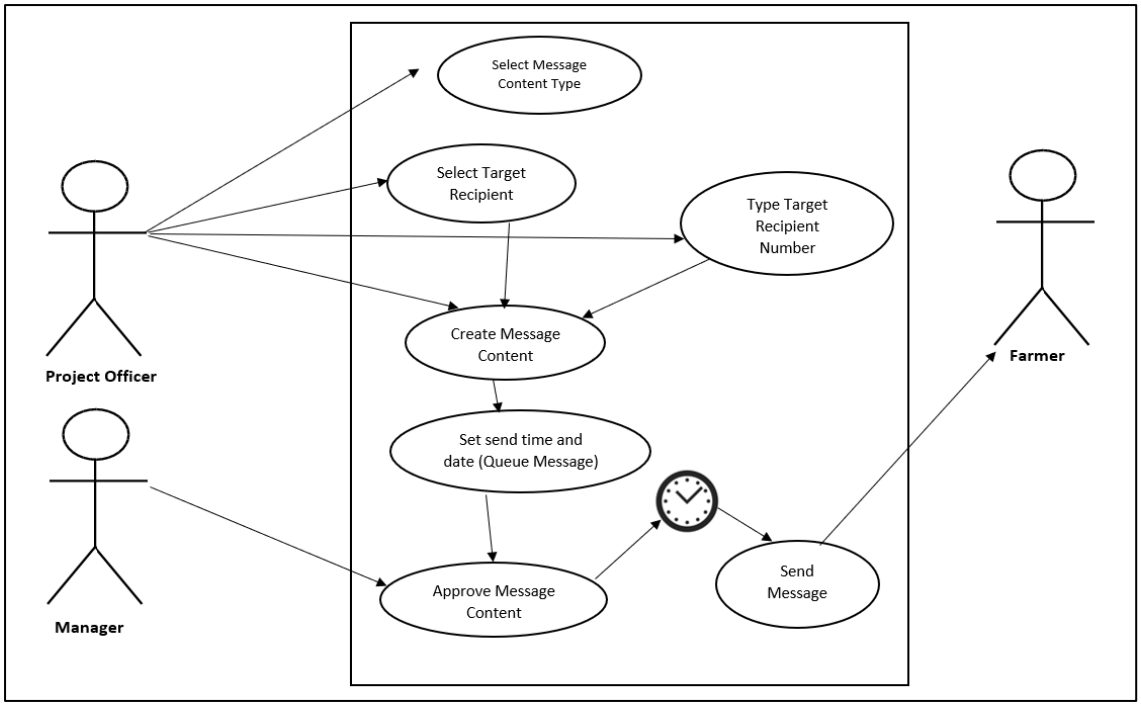

Figure 13: Use Case Model for SMS based messaging system - Iteration 2

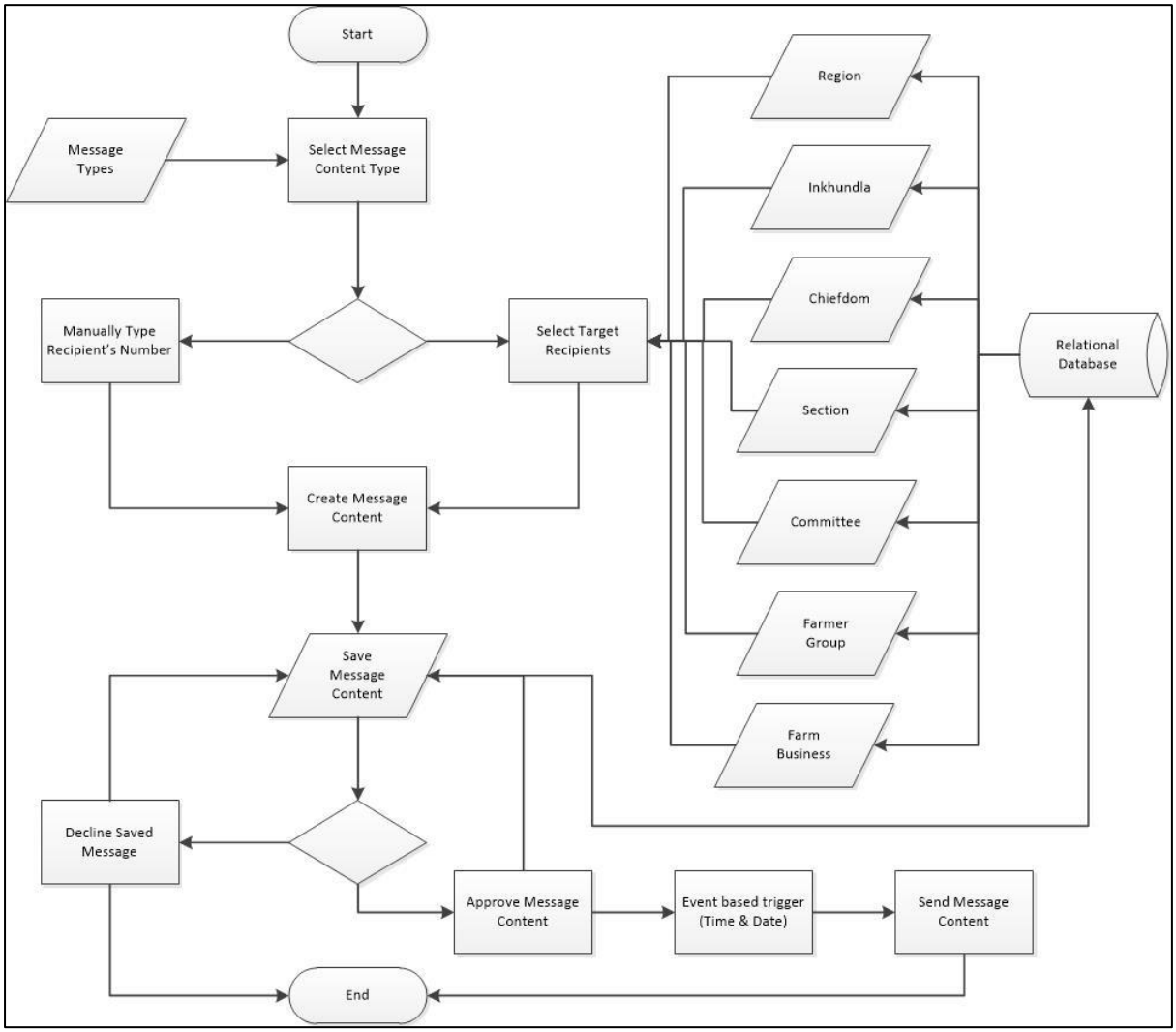

Figure 14: Flow Chart for SMS System – Iteration 2

6.6. Artefact development – Technical Description

The artefact was developed using the Model View Control (MVC) framework using Microsoft Visual Studio and C# as a development language. The underlying database was a Microsoft SQL Server database. The first step in the development was to work on the underlying database. Since the artefact was to leverage information from existing data, we added tables that would be accessed by the system to the existing database. The table descriptions are as follows:

a. **OutboundMessage** – This table captures all the details about the message to be sent i.e. the communication type (weather information, market prices), the individual or the group targeted by the message (Region, Inkhundla, Chiefdom, Section, Farm Group, Committee or Farm Business/Value Chain), send address (which is the number the message was sent from), the user who created the message, the user who updated the message (if updated), approval status (if manager approved messages to be sent) and the time and dates the messages should be sent.
b. **MessageDetail** – This table contains the individual numbers that were targeted to receive messages. This table holds the mobile number, the OutBoundMessage ID so that the system knows the message content sent to the number, time and date it was sent, delivery status and a session ID.
c. **CommsType** – This table contains a list of communication types that can be sent to the farmers, for example, market prices.
d. **Region** – This table contains a list of all the regions in Eswatini
e. **Inkhundla** – This table contains a list of Tinkhundla under each region
f. **Chiefdom** – This table contains a list of Chiefdoms under Inkhundla
g. **Section** – This table contains a list of Sections under each Chiefdom
h. **Committee** – This table contains the different committees that were formed by farmers under the guidance of the project staff
i. **FarmGroup** – This table contains a list of farmers who have come together to form a farm group. These farmers work together in different value chains (farm business) join their resources and produce for a greater harvest or output.
j. **FarmBusiness** – This table contains a list of the different value chains promoted by the project.

Tables (a) and (b) store data related to the messages that are sent to the farmers, capturing all the details that go into each message. Tables (d) to (j) are used to filter the farmers according to their groups.

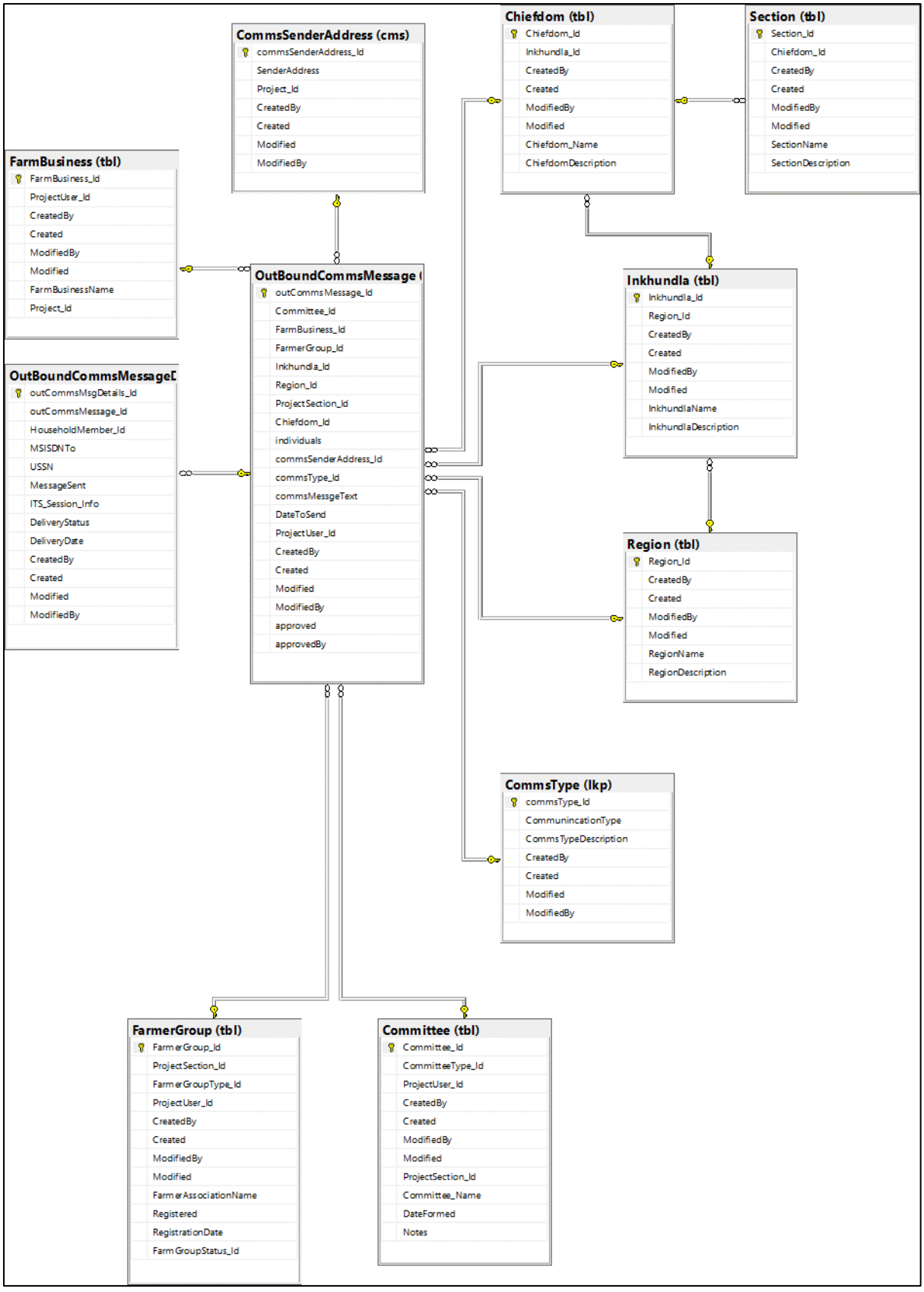

Figure 15: Database structure of the developed artefact

The view from the application provides a graphical user interface for the project officers to send a message to farmers. Once the message is configured and approved to send, the system connects to SMSPortal (https://smsportal.com/) through the provided API. The message is sent to the farmers using a Sender ID (ESWADE-SMLP to ensure that farmers know that the message comes from the organisation and the specific project sending the message. Figure 16 shows the graphical user interface the project officer interacts with. Figure 17 shows the approval screen with a message that has already been approved by the project manager. The approval required the manager to select a tick box and saving the selection. Figure 18 shows the message that has been sent by the project officer on a mobile device, it shows what the message looks like when it arrives on the mobile phone.

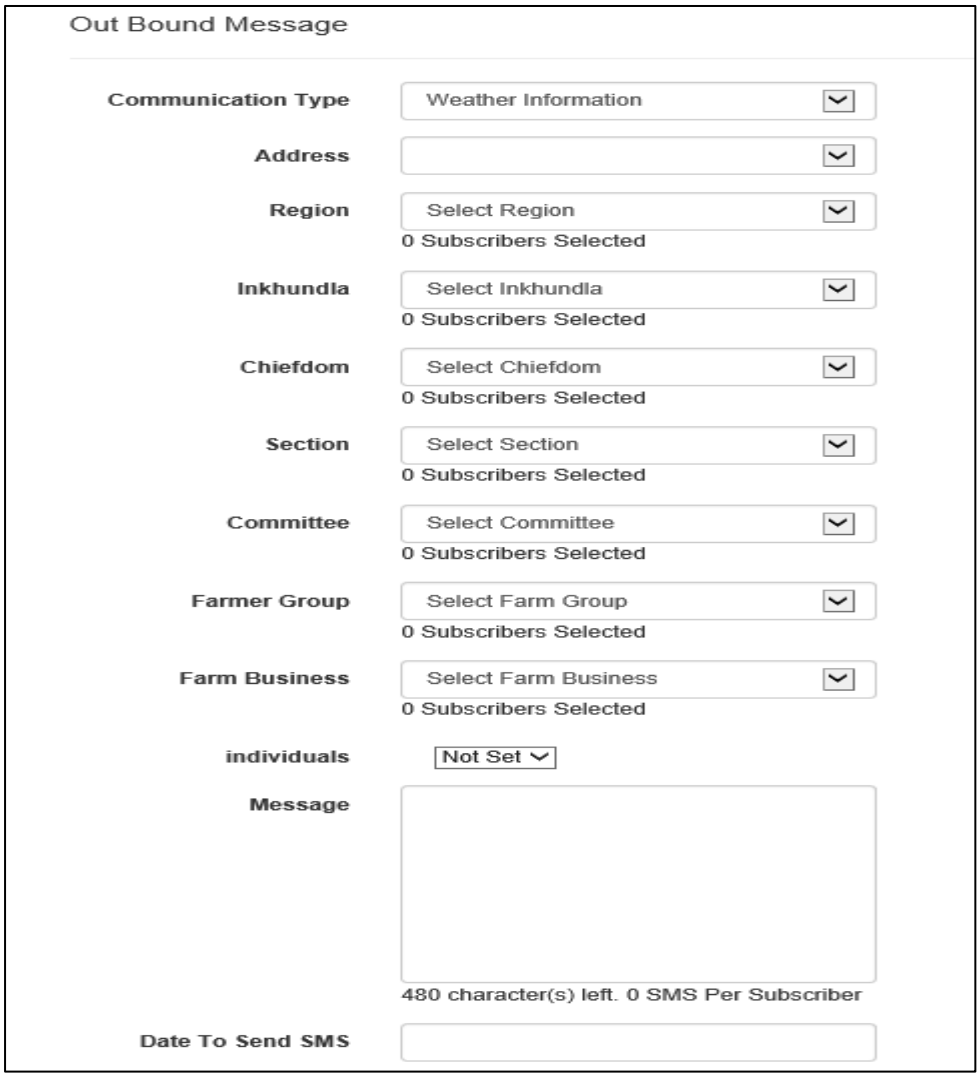

Figure 16: Screen showing message sending console

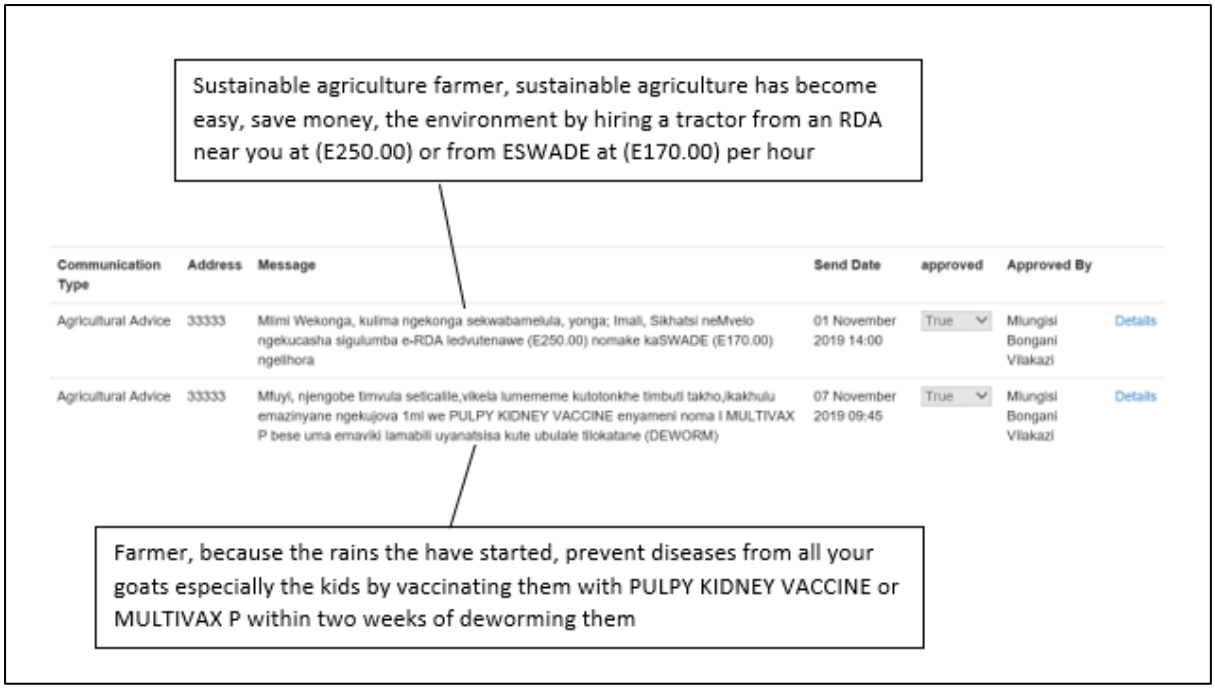

Figure 17: Screen with approved messages to be sent to farmers

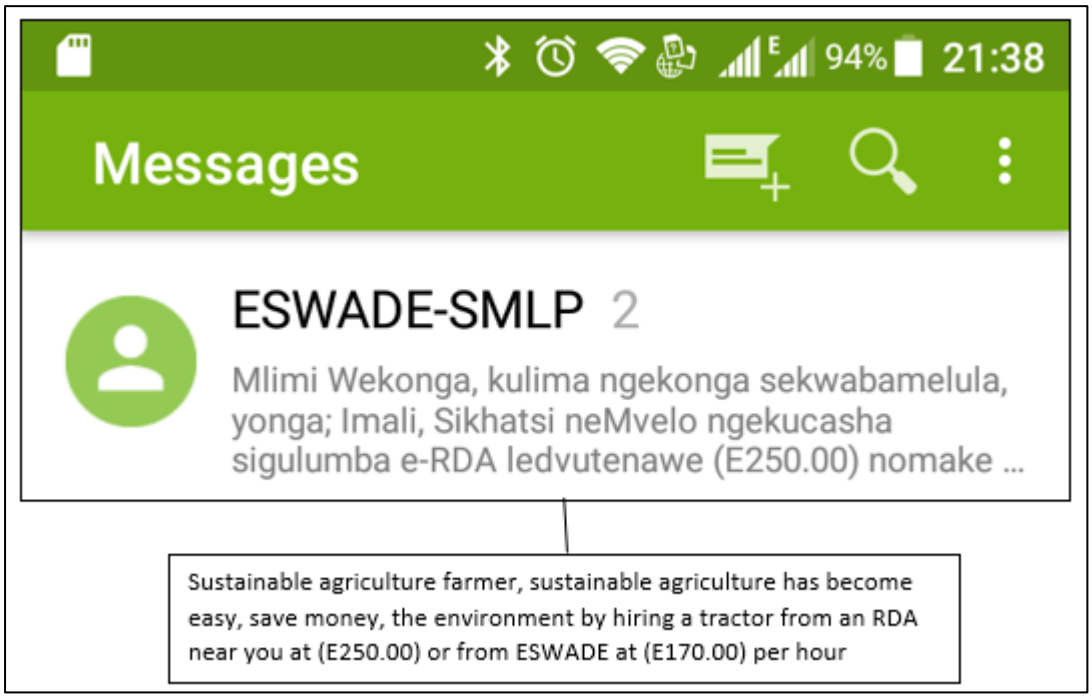

Figure 18: Message received on mobile phone

6.7. Summary

The DSR process and framework were applied in this chapter to design and develop the artefact used by the farmers and project staff. The steps in the DSR process were used to develop the system. The system requirements were sourced through conducting interviews with both farmers and project staff.

In keeping with the DSR process, was conducted a literature search to determine what kind of solution could be developed to solve the research problem. We used a combination of the literature and interview responses to determine the type of solution to be developed. The developed artefact had to meet the needs of both the farmers and project staff. The application of the UTAUT model and the MOPTAM was used to try and predict the use of the system. The system went through two iterations and tests with the farmers and the project staff. This chapter described the process that was undertaken to develop the final iteration of the system.

7. Chapter Seven – Evaluation

7.1. Introduction

This chapter addresses the final stage in the DSR process and framework. The evaluation stage looks at the completed study and developed artefact to determine whether the identified problem has been addressed. This chapter will also re-visits the DSR guidelines to see how the completed study addresses each step in the guidelines. The evaluation stage looks at whether the artefact addresses the research problem and communicates the results and how it contributes to knowledge creation.

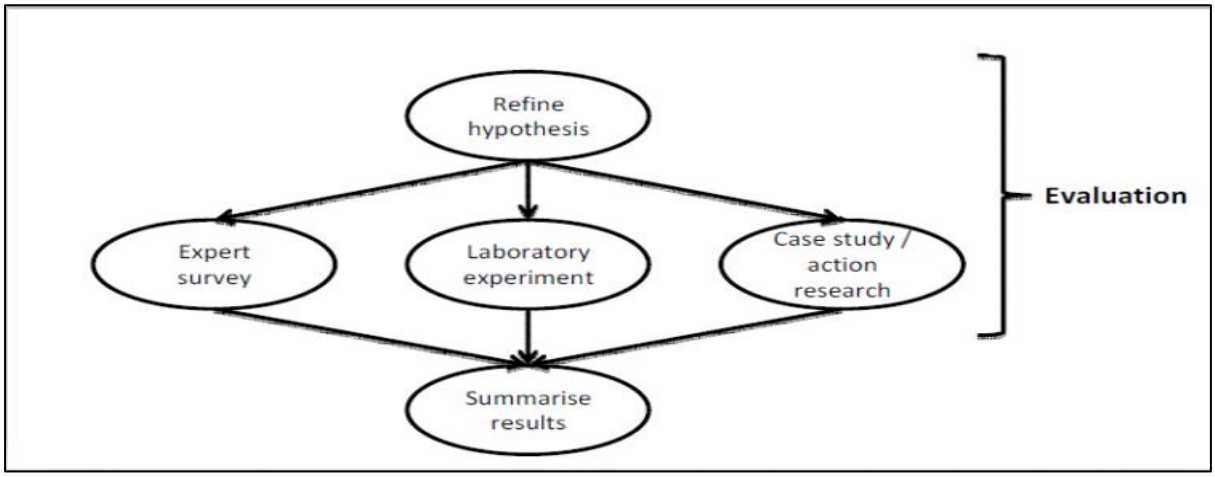

Figure 19: Part of Offermann et al, 2009 DSR Process – Evaluation

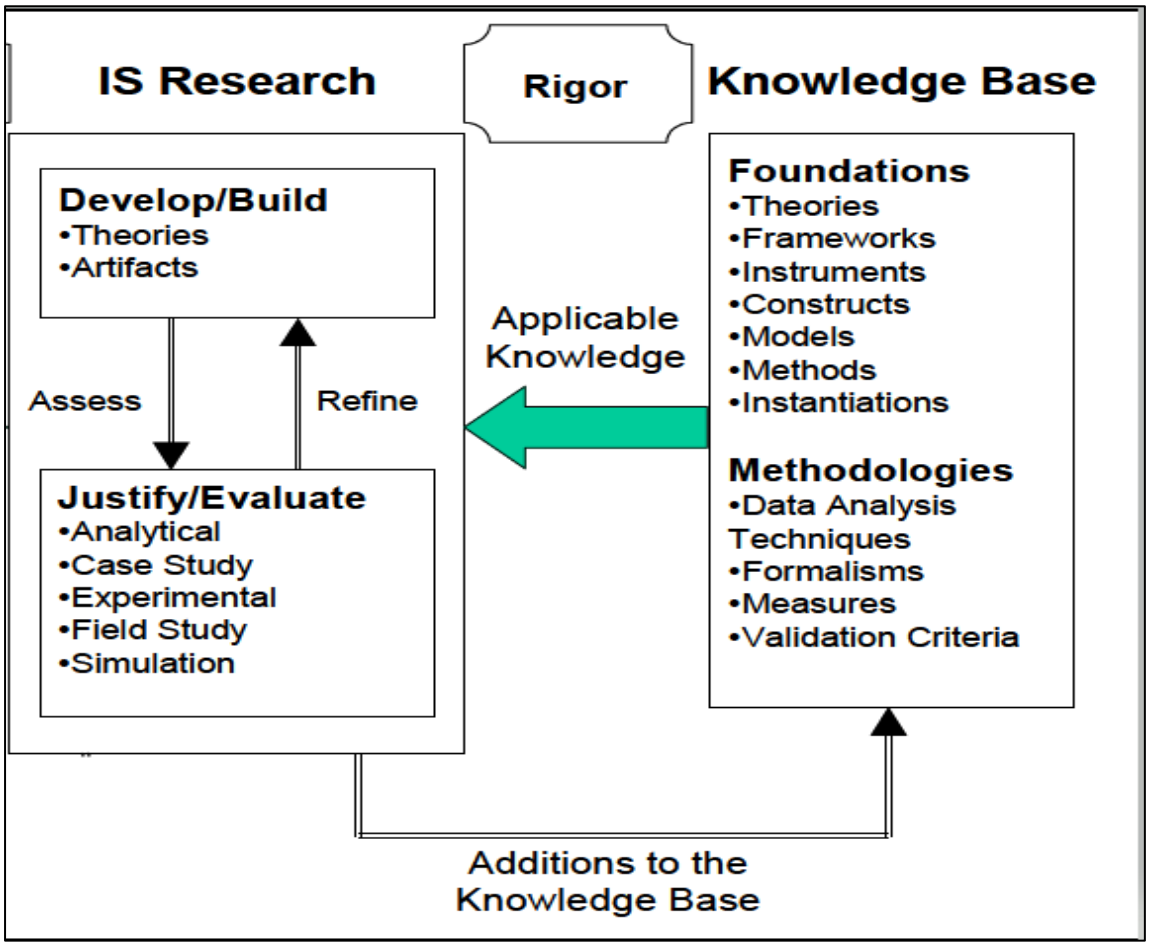

Figure 20: Part of Hevner et al, 2004 DSR Framework – Evaluation

7.2. Evaluation using DSR Guidelines

7.2.1. Guideline 1: Design as an artefact

The developed design artefact was a result of following the steps in the DSR process and framework to answer the research question of this study. The research was conducted to determine if we could develop a system that easily and cost-effectively disseminates information to subsistence farmers. The system would help the SMLP staff easily send information to farmers, and in turn, subsistence farmers would have easy access to timely and reliable information. The artefact that was developed for this study was an SMS based messaging system, developed for the SMLP to send content to farmers. The system allowed project staff to reach a large number of farmers at once and send messages at a time when they still contain relevant information. The benefit for the farmers was that they could receive relevant, reliable and timely information without leaving their homes. The design artefact addressed a real-world problem and was designed following the DSR process and framework.

7.2.2. Guideline 2: Problem relevance

This study aimed to address the difficulty for farmers to access information easily, and the difficulty for the SMLP to disseminate information to farmers and reach a much greater audience at the same time. This challenge emanated from the fact that a lot of farmer engagements were through face-to-face communication. Also, the project development area is vast and the small staff complement means they cannot effectively communicate with the farmers. The farmers needed to access information from a reliable information source and also access information cost-effectively. The artefact aimed to address this disconnect by providing a means for the SMLP to provide information to the farmers who needed it.

7.2.3. Guideline 3: Design evaluation

The artefact was evaluated by getting feedback from both the farmers and project staff. The artefact was very successful at spreading a message to farmers and reaching large numbers simultaneously. This messaging system helped contain an outbreak in fowl pox by giving farmers an early warning to all indigenous chicken farmers to vaccinate their chickens. The project staff revealed that before the availability of the system, they would call lead farmers in a community to spread the message to the rest of the farmers when similar outbreaks occurred. Since, the project area has a lot of communities, staff members would spend the whole day in the office making phone calls to their farmers to tell them about a disease outbreak. Worse, some farmers did not get the message as the lead farmers would communicate with the closest and easiest to access farmers. Efficiently sending messages to all farmers means outbreaks are better controlled as all farmers receive the message at the same time.

The messaging system was also used to mobilise farmers to attend market days organised by the project. It was assumed that the messages sent to farmers would increase the numbers of those who turned up to sell their wares. However, the number of farmers that attended market days did not increase, even though messages were sent. The farmers indicated that they received the messages, but did not feel the need to attend another market day as they had made market contact from previous attendances. The farmers had been able to find buyers for their produce from attending other market days and knew who to sell to once their produce was ready. The messaging

system was also used to announce meetings by sending the date, time and venue for the meeting. The system helped get the message across to all farmers instead of communicating through the lead farmers, thus, the system helped to improve the turnout at meetings.

For the project staff, the system was a very useful means of communication. The project can communicate a consistent message to a large group of farmers. Mass communication is useful for the SMLP because the staff numbers are small, yet they still have to reach a large population pool. The SMLP is better able to deal with outbreaks and can advise farmers on how to best deal with the issue. The SMLP is also able to mobilise farmers for meetings and market days by communicating with each farmer individually instead of sending the message through one contact person. The SMS based system is a cost-effective solution, and this is a vital factor. Each message is sent at a cost of (SZL 0.19 ≈ €0.01), a price which can be further decreased if a larger number of messages are purchased from the bulk SMS provider (https://smsportal.com/). The SMLP covers 100% of the cost of sending the message but once the project ends and all control and resources are handed over to the Ministry of Agriculture, the cost of the messages might be passed to the farmers therefore keeping the costs low becomes critical. The project staff also indicated that the use of messages eliminated the need to advertise in the newspaper because they could now send messages about the market day to farmers directly.

In addition, farmers also found the system very useful in providing them with the much-needed information. Prior to using the system, farmers missed a lot of communication because information came through one contact person. Also, farmers were able to better deal with outbreaks because of the information they received. The system, however, did not cater to questions farmers had after receiving some of the messages. The farmers were not able to send a response if they received a message they did not fully understand or had a follow-up question. This problem was occasionally addressed by placing a contact number in the body of the message but not by the developed artefact. The system needs to better address the two-way communication aspect so that the farmers are able to initiate a message and not just receive information.

7.2.4. Guideline 4: Research contribution

This study demonstrated that the adoption of mobile phones benefits both the farmers and organisations that support them. The SMS based messaging system enabled the SMLP to engage with a lot more farmers, decreasing effort that would have been exerted through face-to-face communication. This paper also showed the effectiveness of an SMS based system to reach farmers for organisations that have little human resources. The contribution to literature made by this study is a perspective that had not been considered in research prior to this. Studying the use of mobile phones in agriculture from both perspectives (consumer and content creator) helps in developing a holistic solution that benefits both parties. The system can impact the operations of both the farmers and those who aim to support farmers as they improve their livelihoods.

7.2.5. Guideline 5: Research rigour

The research applied two models to help in the development of the design artefact. The UTAUT and the MOPTAM were applied in determining the use of the design artefact. The reason for applying two different models was to cater for the differing perspectives that were considered in this study. The UTAUT model considers technology adoption at an organisational level, while the MOPTAM tries

to predict mobile phone adoption. The constructs of the models were used to frame the study and try predict if the artefact being developed will be easily adopted. Applying two different models helped address the needs of the two user groups, the SMLP project staff and the subsistence farmers in the project area.

The application of the two models (UTAUT and MOPTAM) and also following the DSR framework and process ensured that the study is conducted systematically in terms of the planning, data collection, analysis and reporting. Different elements of this study were considered against the categories of DSR framework. First, the environment in which the problem was occurring was clearly identified. We identified elements relevant to understanding the environment such as the people and the technology to get a clear picture of what the problem is and how it fits in its context. Applying knowledge of similar problems from other studies also helped in contextualising the problem and possibly finding solutions. Following the directions of the DSR framework ensured that the study is conducted rigorously and systematically.

7.2.6. Guideline 6: Design as a search process

The development of the design artefact followed the steps proposed in the DSR process. Once the problem is identified through literature search and interviews with project staff, the information is evaluated and a possible solution is proposed. The proposed artefact is designed and further refined through literature search, similar solutions that have been proposed in other studies help in developing and refining an artefact for the study. The solution is then tested to determine if it meets the needs of all the stakeholders and whether it answers the research question. These steps are all in line with the steps described in the DSR process and implemented in a number of iterations until the artefact matches or is as close as possible to resolve the research problem.

7.2.7. Guideline 7: Communication of research

The findings of this research were communicated through the creation of this dissertation document, detailing the steps taken in answering the research question. The research was also shared with the academic world through writing a condensed version of the findings for the 11th International Development Informatics Association Conference (IDIA2020), hosted by the United Nations University in Macau.

8. Chapter Eight – Conclusion, Recommendations and Future Considerations

Agriculture is still a major part of Eswatini's economy and the farmers need as much support as possible to develop and produce enough agricultural output to improve their livelihoods. Information is still a crucial aspect of enabling farmers to improve their agricultural output. Mobile phones have played an important role in agriculture by improving the means of disseminating information.

Research in the field of mobile phones in agriculture already shows a lot of the benefits farmers gain from using a mobile phone in agriculture. The research in this field places a lot of emphasis on the farmers receiving reliable and quality information. The source of the provided information has been a missing link for a while in the research field, yet organisations that provide farmers with information also benefit from farmers leveraging technology. When both the farmers and organisations supporting them adopt technology, their engagements are improved and simplified.

As shown earlier, information needs of farmers in Eswatini are typically similar to those experienced by farmers in other developing countries. The interviews with farmers and project staff showed that farmers still need a lot of help determining the type of agriculture to practice. Farmers need help understanding the type of agriculture to practice in their different environments, how to determine if their produce is healthy and how to find a market. The information needed by farmers is typically available in organisations setup to help farmers improve their agricultural potential. However, it becomes difficult to distribute this information to farmers because they are in remote locations.

The finding of this paper shows that the SMLP, the project studied, benefited from farmers adopting mobile phones as that made it easier for them to communicate with the farmers. More so because, the project covers a large area and has limited staff numbers to reach a huge population. The adoption of technology by both the farmers and SMLP meant they could communicate some messages to a big group of farmers simultaneously. Communicating with farmers through the messaging system saved the project staff a lot of time and effort.

Utilising the messaging system helped communicate information about disease outbreaks and how to control them. Communicating messages through lead farmers proved to be ineffective as the message did not always reach the intended recipients. The system was also good at mobilising farmers to attend meetings because each farmer could be contacted ahead of time. However, sending messages to farmers to attend market days did not result in the expected outcome. That is, notifying the farmers about market days did not result in increased attendance by farmers or repeat attendance by farmers. Farmers used market days to gain access to markets or buyers and once they had identified a buyer they could sell to continually, they did not see value in attending future market days.

The developed artefact was effective at reaching a large number of farmers through the use of SMS. Nonetheless, the artefact was limited in that the messaging was one-way communication, the project staff could send messages to farmers but the farmers could not send messages back. This was a big drawback because farmers could not follow up on messages they did not understand and they could not initiate a message to get information from the project staff. This indicates that there is still much room for the developed artefact to improve so that it better meets the needs of both

the farmers and project staff. The already identified drawback of one-way communication is a major one, but there are other limitations that need to be taken into consideration. SMS is a good way of sending important messages but there is a slight challenge with archiving messages for future reference. If a message is deleted from the device the user no longer has access to that information. Other functions available on the mobile phone, like USSD could be used so that the messages are always available for farmers to view. Moreover, the artefact in its current form only benefits farmers who know how to read. The use of IVR could help address the issue of providing messages to farmers who cannot read and this could also allow the project to communicate longer messages.

The messaging system could be applied in other countries that have a demographic structure and challenges similar to those of Eswatini. The system is effective at communicating messages to large populations when human resources are limited and farmers live in rural or remote locations. With limited adaption like changing the administration structure of Region, Inkhundla, Chiefdom and Section and applying the relevant structure, the system could be applied in countries like Lesotho. Applying other consideration like USSD and IVR could further improve the offering of the system and create a holistic system that caters to the needs of all types of farmers.

This study demonstrated how the use of mobile phones in agriculture is beneficial. Looking at the study from two angles shows that the benefit is not only received by the farmers but also by the supporting organisations. This topic needs to be studied from both angles to be able to develop a system and applications that benefit both parties. The study also demonstrated the effectiveness of using SMS in projects with limited resources that need to benefit a large poll of beneficiaries. There is still further work that needs to be done on the artefact and this study to further improve the relationship between farmers and the organisations supporting them.

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Appendices

Appendix A: Interview Procedure

1	STEPS FOR CONDUCTING THE INTERVIEWS
1.1. Greeting of participant and self-introduction 1.2. Explain research and request permission to conduct interview 1.3. Obtain consent from participant 1.4. Request permission to record interview 1.5. Describe process that will be followed during the interview 1.6. Proceed with the interview 1.7. Take notes 1.8. Take questions and feedback 1.9. Summarise and clarify key responses 1.10. Finalise interview and thank participant for their time	
2	**POST INTERVIEWS PROCEDURE**
2.1. Upload recording to a secured drive 2.2. Transcribe recordings and combine with notes 2.3. Store transcribed recordings to secure drive	

Appendix B: Interview Questions – Crop Production

Interviews

Interview Questions

Access to Information

1. What agricultural information do you need access to that would help you improve your production?
   Nguluphi lwati lwetekulima/netekufuya loludzingako nalolungakusita kutsi umkhicito wakho ube ngulosezingeni?

2. What information do you currently have access to?
   Nguluphi lwati lwetekulima nekufuya lolufinyelela kuwe?

3. How do you normally gain access to the agricultural information that you specified above?
   Uvame kulutfola njani lwati mayelana netelulimo nemfuyo mayelana nemphendvulo loyivete kulombuto longetulu?

4. Does the agricultural information get delivered in a format that is understandable and usable to you?
   Lolwati luvame kutfolakala ngendlela levakalako nalesebentisekako yini?

5. What information would you be willing to pay for and how much are you willing to pay?
   Nguluphi lwati longatsandza kulibhadalela, ungalungela kubhadala malini?

6. How much are you prepared to spend (i.e. data, calls or SMS) to get access to information?
   Ulungela kusebentisa malini kutebucwephesha?) Loku kungaba yi data, kushaya lucingo noma kutfumela umlayeto) kute utfole lwati?

7. In which manner can agricultural information be delivered to that would be convenient for you to access?
   Nguyiphi indlela loyibona kutsi ingakusebentela mayelana nekutfola lwati ngetekulima?

8. How do you get information on specific questions related to individual problems/concerns or general information you have?
   Ulutfola njani lwati mayelana nemibuto letsite letimayelana netinkinga longaba nato, tikhalo noma lwati longaba nalo?

9. How do you get access to weather information?
   Usitfola njani simo selitulu?

10. How do you get access to market prices?
    Ulutfola njani lwati mayelana nentsengo yetimakethe?

11. How do you determine what price to sell your produce at?
    Yini leyenta wati kutsi tilimo takho noma imfuyo utayitsengisa ngentsengo lengakanani?

12. How do you get information on what type of crop to plant with the different varieties of soil types?
    Ulutfola kanjani lwati mayelana nekutsi yini lefuna kuhlanyelwa ikakhulu mayelana nemihlaba leyahlukahlukene?

13. How do you get information on farming inputs and specials available for the inputs?
    Ulutfola njani lwati mayelana netinhlanyelo kanye nekutsi intsengo lephansi itfolakala kuphi?

14. How do you get information on plants diseases?
    Ulutfola kanjani lwati mayelana netifo letihlasela tilimo letihlanyelwe?

15. How do you diagnose plant diseases?
    Usenta kanjani siciniseko sekutsi sifo lesihlasele tililimo singusiphi futsi singiso yini?

16. How do you get information on how to treat plant disease?
    Ulutfola kanjani lwati mayelana nekutsi sifo singelashwa kanjani kuloko lokulinyiwe?

17. How do you get access to markets and the prices that are currently on offer?
    Ulutfola njani lwati mayelana netimakethe nentsengo letfolakala etimakethe?

18. How do you make offers to a large group of buyers if you have had a good harvest?
    Uma kwentekile watfola sivuno lesihle nalesinengi, ulitsengisela njani linyenti?

Markets

19. How do you get access to market prices?
    Ulutfola njani lwati mayelana nentsengo yetimakethe?

20. How do you determine what price to sell your produce at?
    Yini leyenta wati kutsi tilimo takho noma imfuyo utayitsengisa ngentsengo lengakanani?

21. How do you get access to markets and the prices that are currently on offer?
    Ulutfola njani lwati mayelana netimakethe nentsengo letfolakala etimakethe?

22. How do you make offers to a large group of buyers if you have had a good harvest?
    Uma kwentekile watfola sivuno lesihle nalesinengi, ulitsengisela njani linyenti?

Appendix C: Interview Questions – Livestock Production

Interviews

Interview Questions

Access to Information

1. What agricultural information do you need access to that would help you improve your production?
   Nguluphi lwati lwetekulima/netekufuya loludzingako nalolungakusita kutsi umkhicito wakho ube ngulosezingeni?

2. What information do you currently have access to?
   Nguluphi lwati lwetekulima nekufuya lolufinyelela kuwe?

3. How do you normally gain access to the agricultural information that you specified above?
   Uvame kulutfola njani lwati mayelana netelulimo nemfuyo mayelana nemphendvulo loyivete kulombuto longetulu?

4. Does the agricultural information get delivered in a format that is understandable and usable to you?
   Lolwati luvame kutfolakala ngendlela levakalako nalesebentisekako yini?

5. What information would you be willing to pay for and how much are you willing to pay?
   Nguluphi lwati longatsandza kulibhadalela, ungalungela kubhadala malini?

6. How much are you prepared to spend (i.e. data, calls or SMS) to get access to information?
   Ulungela kusebentisa malini kutebucwephesha?) Loku kungaba yi data, kushaya lucingo noma kutfumela umlayeto) kute utfole lwati?

7. In which manner can agricultural information be delivered to that would be convenient for you to access?
   Nguyiphi indlela loyibona kutsi ingakusebentela mayelana nekutfola lwati ngetekulima?

8. How do you get information on specific questions related to individual problems/concerns or general information you have?
   Ulutfola njani lwati mayelana nemibuto letsite letimayelana netinkinga longaba nato, tikhalo noma lwati longaba nalo?

9. How do you access extension services?
   Ulutfola njani lwati mayelana netelulimo

Markets

10. How do you get access to market prices?
    Ulutfola njani lwati mayelana nentsengo yetimakethe?

11. How do you determine what price to sell your produce at?
    Yini leyenta wati kutsi tilimo takho noma imfuyo utayitsengisa ngentsengo lengakanani?

12. How do you get access to markets and the prices that are currently on offer?
    Ulutfola njani lwati mayelana netimakethe nentsengo letfolakala etimakethe?

13. How do you make offers to a large group of buyers if you have had a good harvest?
    Uma kwentekile watfola sivuno lesihle nalesinengi, ulitsengisela njani linyenti?

Mobile Phone

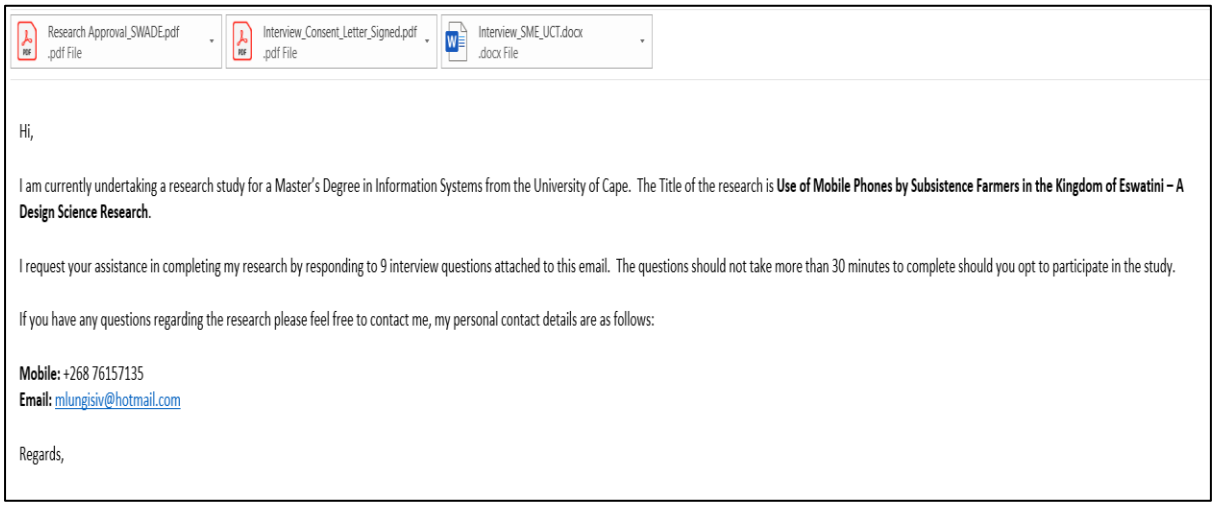
14. Do you own or have access to a mobile phone? What type of mobile phone is it?
    Unalo lucingo lwamahlalekhukhwini noma lenye inhlobo yelucingo? Uma unalo nguliphi?

15. How familiar are you with the functions and features on your mobile phone, which features do you use most?
    Ukwati kangakanani kulusebentisa lolucingofutsi linatinhlangotsi tiphi? Ngutiphi tinhlangotsi lotisebentisa kakhulu?

16. Do you own or have access to any other technology, such as computer, that you use to obtain agricultural information?
    Unaye yini ngcondvomshina noma lkhona yini lenye indlela lotfola ngayo tebucwephesha loyisebentisa kutfola lwati mayelana netekulima?

17. How familiar are you with the technology and its features?
    Ukwati kangakanani kusenbentisa tebucwephesha Kanye netinhlangotsi takhona?

Appendix D: Interview Request – Subject Matter Experts


Research Approval_SWADE.pdf
.pdf File

Interview_Consent_Letter_Signed.pdf
.pdf File

Interview_SME_UCT.docx
.docx File

Hi,

I am currently undertaking a research study for a Master's Degree in Information Systems from the University of Cape. The Title of the research is **Use of Mobile Phones by Subsistence Farmers in the Kingdom of Eswatini – A Design Science Research**.

I request your assistance in completing my research by responding to 9 interview questions attached to this email. The questions should not take more than 30 minutes to complete should you opt to participate in the study.

If you have any questions regarding the research please feel free to contact me, my personal contact details are as follows:

Mobile: +268 76157135
Email: mlungisiv@hotmail.com

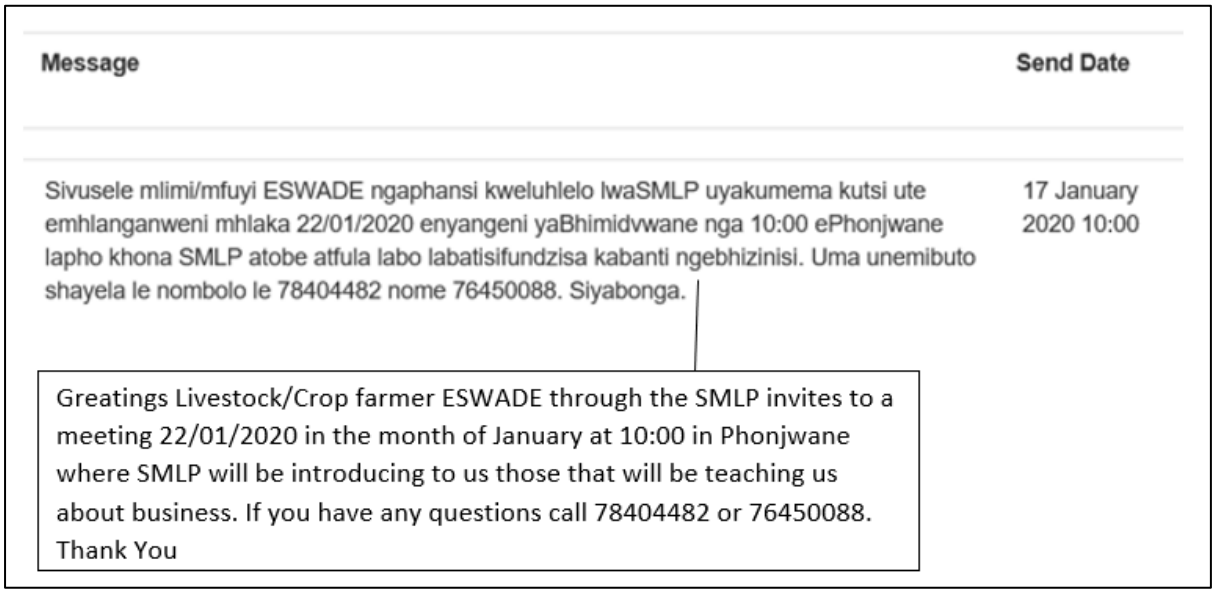
Regards,

Appendix F: Interview Questions – Subject Matter Experts

Subject Matter Experts

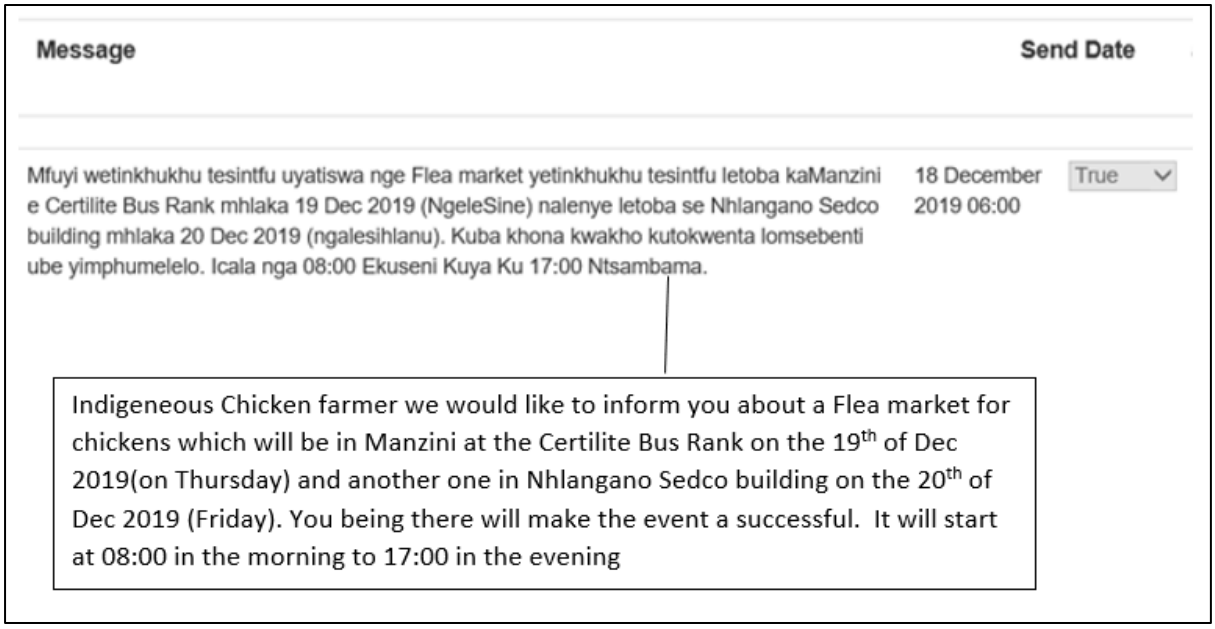
1. What information is currently available to the farmers and what is the source of this information?
2. How is this information currently delivered to the farmers?
3. Do the farmers have the resources and capabilities to access and use the information that is currently available?
4. How is the information that is available updated to ensure it is accurate and up to date?
5. What information would be useful to their farmers in helping improve their production?
6. How best can this information be delivered to the farmers that is easily accessible?
7. How do farmers send questions that related individual issues or concerns?
8. How are these issues currently being addressed and how does the farmer get a response?
9. How would you suggest information be disseminated to the farmers, does not have to be system related?

Appendix G: Examples of Messages Sent on the System



Message	Send Date
Sivusele mlimi/mfuyi ESWADE ngaphansi kweluhlelo lwaSMLP uyakumema kutsi ute emhlanganweni mhlaka 22/01/2020 enyangeni yaBhimidvwane nga 10:00 ePhonjwane lapho khona SMLP atobe atfula labo labatisifundzisa kabanti ngebhizinisi. Uma unemibuto shayela le nombolo le 78404482 nome 76450088. Siyabonga.	17 January 2020 10:00

Greatings Livestock/Crop farmer ESWADE through the SMLP invites to a meeting 22/01/2020 in the month of January at 10:00 in Phonjwane where SMLP will be introducing to us those that will be teaching us about business. If you have any questions call 78404482 or 76450088. Thank You



Message	Send Date	
Mfuyi wetinkhukhu tesintfu uyatiswa nge Flea market yetinkhukhu tesintfu letoba kaManzini e Certilite Bus Rank mhlaka 19 Dec 2019 (NgeleSine) nalenye letoba se Nhlangano Sedco building mhlaka 20 Dec 2019 (ngalesihlanu). Kuba khona kwakho kutokwenta lomsebenti ube yimphumelelo. Icala nga 08:00 Ekuseni Kuya Ku 17:00 Ntsambama.	18 December 2019 06:00	True

Indigeneous Chicken farmer we would like to inform you about a Flea market for chickens which will be in Manzini at the Certilite Bus Rank on the 19th of Dec 2019(on Thursday) and another one in Nhlangano Sedco building on the 20th of Dec 2019 (Friday). You being there will make the event a successful. It will start at 08:00 in the morning to 17:00 in the evening

Message	Send Date
Mfuyi wetinkhukhu tesintfu uyatiswa nge Flea market yetinkhukhu tesintfu letoba kaManzini e Certilite Bus Rank mhlaka 19 Dec 2019 (NgeleSine) nalenye letoba se Nhlangano Sedco building mhlaka 20 Dec 2019 (ngalesihlanu). Kuba khona kwakho kutokwenta lomsebenti ube yimphumelelo. Icala nga 08:00 Ekuseni Kuya Ku 17:00 Ntsambama.	18 December 2019 06:00

Indigeneous Chicken farmer we would like to inform you about a Flea market for chickens which will be in Manzini at the Certilite Bus Rank on the 19th of Dec 2019(on Thursday) and another one in Nhlangano Sedco building on the 20th of Dec 2019 (Friday). You being there will make the event a successful. It will start at 08:00 in the morning to 17:00 in the evening

Message	Send Date
Vikelisa emangcumbula emantjwele akho Kanye netinkhukhu tonkhe. Wavikelise nge fowl pox vaccine nakanemalanga lasikhombisa, uwaphindze nakana 14 wemalanaga bese ugcina nakana 21 wemalanga. Kulandzela kutsi emangcumbula sifo lesingalapheki akavikelwe mfuyi kute siphephe.	17 January 2020 10:00

Protect your chicks and your chickens against fowl pox. Vaccinate with fowl pox vaccine when they are 7 days old and again when they are 14 days old and finally when they 21 days old. Seeing that fowl pox can't be treated you need to make sure you vaccinate.

Appendix H: Ethical Approval

Faculty of Commerce

Private Bag X3, Rondebosch, 7701
2.26 Leslie Commerce Building, Upper Campus
Tel: +27 (0) 21 650 4375/ 5748 Fax: +27 (0) 21 650 4369
E-mail: com-faculty@uct.ac.za
Internet: www.uct.ac.za
@Commerce UCT **UCT Commerce Faculty Office**

28 January 2019

Mr Mlungisi Vilakazi
Department of Information Systems
University of Cape Town

Dear Mlungisi Vilakazi,

REF: REC 2018/012/167

USE OF MOBILE PHONES BY SUBSISTENCE FARMERS IN THE KINGDOM OF ESWATINI - A DESIGN SCIENCE RESEARCH

We are pleased to inform you that your ethics application has been approved. Unless otherwise specified this ethical clearance is valid for 1 year and may be renewed upon application.

Please be aware that you need to notify the Ethics Committee immediately should any aspect of your study regarding the engagement with participants as approved in this application, change. This may include aspects such as changes to the research design, questionnaires, or choice of participants.

The ongoing ethical conduct throughout the duration of the study remains the responsibility of the principal investigator.

We wish you well for your research.

Shandre Swain
Administrative Assistant
University of Cape Town
Commerce Faculty Office
Room 2.26 | Leslie Commerce Building

Office Telephone: +27 (0)21 650 2695 / 4375
Office Fax: +27 (0)21 650 4369
E-mail: sl.swain@uct.ac.za
Website: www.commerce.uct.ac.za<http://www.commerce.uct.ac.za/

Appendix I: Research Approval - ESWADE

ESWADE
Making A Difference

Sincephetelo MVA Building |
3rd Floor, Mbhilibhi Street | Mbabane, Swaziland | P.O. Box
5836 Tel: (+268) 2404 7950/1 | Fax: (+268) 2404 7954
Email: swade@swade.co.sz | Web: www.swade.co.sz

Eswatini Water & Agricultural Development Enterprise

Our Ref: SWADE/GEN **04 March 2019**

Attention: MR Mlungisi Vilakazi

Re: AMIS/SMLP System for Disseminating Information to Farmers

We acknowledge receipt of your letter requesting permission to study the process of upgrading the AMIS system to disseminate information to the farmers the project is currently working with.

We consent to your study utilizing SWADE information for your research work.

Wishing you the best in your studies

Yours Faithfully

Signature Removed

Samson Sithole
Chief Executive Officer

Appendix J: Consent Letter

University of Cape Town
Department of Information Systems
Leslie Commerce Building, Upper Campus
Private Bag. Rondebosch 7701
Cape Town, South Africa
Tel: +27 (0) 21 650 4028

Dear Sir/Madam,

I am a full-time Masters' student of the Department of Information Systems at the University of Cape Town. I am carrying out a study titled "*Use of Mobile Phones by Subsistence Farmers in the Kingdom of eSwatini - A Design Science Research*". The study in which your consent is sought has been approved by the ethics committee of the Faculty of Commerce, University of Cape Town.

The purpose of this study is to determine what improvements can be made to the AMIS system to better disseminate market and agricultural information to subsistence farmers in Kingdom of eSwatini. Your participation in this research by means of an interview will be highly appreciated.

Your participation is completely voluntary, you may terminate the interview at any point in case you feel uncomfortable with the questions. You are not required to provide any specific identifiable information for this interview and all information will be treated as confidential and used for the purpose of this study only. The findings of this study will be compiled and presented to the University of Cape Town for academic purposes. Participants' details will not be published as part of the report and all participants will remain anonymous.

The interview is expected to take about 30 minutes; if you opt to participate you may verbally confirm your approval. If you have any questions regarding this study kindly contact Mlungisi Vilakazi or Prof JP Van Belle

Yours sincerely,

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Appendix K: SMLP Project Development Area

Tinkhundla - administrative subdivision smaller than a region	Chiefdom - subdivision smaller than Inkhundla
Siphofaneni	Hlutse; Mphumakudze; Vikizijula; KaPhunga; Madlenya; Mkhweli; Lesibovu
Sithobela	Nceka; Luhlanyeni; Mamisa; Nkonjwa
Lubuli	Zulwini
Sigwe	Lulakeni
Hosea	Nyatsini; Liba; Ondiyaneni; Ngololweni;
Sandleni	Nzameya; Nhletjeni
Mtsambama	Magele; KaMbhoke; Kwendzeni; Bhanganoma
Kubuta	Zishineni; Lushini; Nhlalabantfu
Matsantjeni South	Nqomintaba
Ngudzeni	Mhawu; Lusitini; Mkhaya; Ndushulweni
Ntondozi	Ntondozi; Mphini; Kandinda
Mafutseni	Mafutseni

Map Showing SMLP Tinkhundla and Chiefdoms