Integration of information and communication technology (ICT) in the development of a recordkeeping database of smallholder sheep farming systems in the Western Cape Province of South Africa

by

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Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

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Abstract

The use of smartphone technology generates new opportunities for better farm and livestock management. The constant use of traditional systems by smallholder livestock farmers for recordkeeping in developing countries faces risks of poor farm management, inbreeding, high mortality and low offtake rates. The main objective of the study was to design and develop a recordkeeping database for smallholder sheep farmers in Beaufort West and Ebenheazer communities to improve the sustainable production of sheep. A survey based on SWOT analysis and in-depth interview using a semi-structured questionnaire was conducted. It sought to identify and assess the features to include in the development of the web-application database, the challenges and benefits of the farmers current recording and recordkeeping methods. The collection of data was between April and August 2018 with 24 participants taking part in the study. The SWOT analysis and questionnaire assisted with the identification and characterization of ecological and socio-economic challenges affecting the sustainability of sheep farming in both communities. This study used a sequential exploratory mixed method approach. The approach uses both qualitative and quantitative analysis for data analysis. The farmers assisted in the design and development of the web-application by identifying important features to add on the platform and further indicated their willingness to support the development of the application. The results showed that farmers were willing to support the development of the application and using the database. In addition, the results showed that male farmers were the majority in both communities (88%), whilst about 79% indicated livestock farming as the main source of income. The majority of farmers (above 50%) reported that change in weather patterns especially drought as a challenge to sustainable sheep production. There was no association between the willingness of the farmer to use a recordkeeping database with attributes such as, level of education of the farmer, district and source of income. However, there was association between the willingness of the farmer to use a recordkeeping database and age. The younger the farmer the more a farmer was willing to use the database. The farmers also stated that traditional recording and recordkeeping using a pen and a paper was a challenge, monotonous and tiresome. The main source of acquiring information for both communities is through government extension officers (50%) followed by other farmers (28%). The study determines that smallholder sheep farmers assisted in the identification and characterization of the features necessary for the development of the database. In this study, the active participation of the farmers allowed the development of a management database system. The farmers identified sheep pedigree information such as date of birth, body condition score, weight, lambs born, sheep identification number, sheep breed and the farmers profile which include location, farmer name and farm name as some of the input variable necessary to be included.

Keywords: web-application, sustainable, development, recordkeeping, recording, information

Opsomming

Die gebruik van slimfoon tegnologie genereer nuwe geleenthede vir beter plaas- en veebestuur. Die hoofdoel van die studie was om 'n rekordhouding databasis vir kleinvee-skaapboere in Beaufort-Wes en Ebenheazer-gemeenskappe te ontwerp en te ontwikkel om die volhoubare produksie van skape te verbeter. 'N SWOT-analise en 'n semi-gestruktureerde opname om die eienskappe te evalueer en te identifiseer in die ontwikkeling van die webtoepassingsdatabasis, die uitdagings en voordele van die huidige opname- en rekordhoudingmetodes van boere. Die versameling van data was tussen April en Augustus 2018 met 24 deelnemers wat aan die studie deelgeneem het. Die SWOT-analise en vraelys het gehelp met die identifisering en karakterisering van ekologiese en sosio-ekonomiese uitdagings wat die volhoubaarheid van skaapboerdery in beide gemeenskappe beïnvloed. Hierdie studie het 'n gemengde metodebenadering gebruik; daarom het die studie beide kwalitatiewe en kwantitatiewe analise vir data-analise gebruik. Die boere het gehelp met die ontwerp en ontwikkeling van die webtoepassing deur belangrike eienskappe op die platform te identifiseer en het verder aangedui dat hulle bereid is om die ontwikkeling van die aansoek te ondersteun. Die resultate het getoon dat boere bereid was om die ontwikkeling van die aansoek te ondersteun en die databasis te gebruik. Daarbenewens het die resultate getoon dat manlike boere die meerderheid in beide gemeenskappe (88%) was, terwyl ongeveer 79% lewendehawe as hoofbron van inkomste aangedui het. Die meerderheid boere (bo 50%) het berig dat verandering in weerpatrone, veral droogte, as 'n uitdaging vir volhoubare skape produksie. Daar was geen verband tussen die bereidwilligheid van die boer om 'n rekordhouding databasis te gebruik met eienskappe soos die onderwyser se vlak van onderwys, distrik en inkomstebron. Daar was egter 'n verband tussen die bereidwilligheid van die boer om 'n rekordhoudende databasis en ouderdom te gebruik. Hoe jonger die boer, hoe meer 'n boer bereid was om die databasis te gebruik. Die boere het ook gesê dat tradisionele opname en rekordhouding met behulp van 'n pen en papier 'n uitdaging was, eentonig en vermoeiend. Die hoofbron vir die verkryging van inligting vir beide gemeenskappe is deur die regering se voorligtingsbeamptes (50%), gevolg deur ander boere (28%). Die studie bepaal dat kleinvee-skaapboere bygestaan het in die identifisering en karakterisering van die eienskappe wat nodig is vir die ontwikkeling van die databasis. In hierdie studie het die aktiewe deelname van die boere die ontwikkeling van 'n bestuursdatabasisstelsel toegelaat. Die boere het skape se stamboek inligting soos geboortedatum, liggaamsvoorwaarde telling, gewig, lammers gebore, skape identifikasie nommer, skape ras en die boereprofiel wat plek, boer naam en plaasnaam bevat, aangesien sommige van die inset veranderlike nodig is om ingesluit te word.

Sleutelwoorde: webtoepassing, volhoubare ontwikkeling, rekordhouding, opname, inligting

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List of Acronyms

SDGs	Sustainable Development Goals
GDP	Gross Domestic Product
SA	South Africa
ICT	Information and Communication Technology
SMS	Short Message Service
SSA	sub-Saharan Africa
DAFF	Department of Agriculture, Fish and Forestry
EGCI	Esoko Ghana Commodity Exchange
GIS	Geographical Information Systems
M-PESA	Mobile Payment (Kenya)
KACE	Kenyan Agricultural Commodity Exchange
MACE	Malawian Agricultural Commodity Exchange
DMS	Data Management System
RFID	Radio Frequency Identification
FAO	Food and Agriculture Organisation
TV	Television
ABALOBI	Xhosa name for Fisherman

CHAPTER 1. Introduction

1.1 Background

The agriculture sector continues to ensure sustainable futures, rural development and poverty reduction in the 21st century (The World Bank, 2008; Tijjani, Anaeto and Emerhirhi, 2017). Moreover, in Sub-Saharan Africa, smallholder farmers, especially in rural areas, depend directly or indirectly on agriculture (Altman, Hart and Jacobs, 2009). The smallholder farmers play a role towards contributing to food security and poverty alleviation in most developing countries (Herrero et al., 2014). In South Africa, agriculture is one of the sectors that contribute towards the positive gross domestic product (GDP) of the country (Hlomendlini et al., 2017), including forestry and fisheries. According to the report of DAFF, (2013), the agriculture sector for 2015/16 in South Africa contributed an estimated total of R247 098 million to the GDP, with a 9.1% increase from the previous year. Evidence from the previous research further suggests that agriculture is expected to feed the growing number of population of more urban-based citizens with higher income and different food preferences (The World Bank, 2008; Musvoto et al., 2015; Smith et al., 2017; Bedhiaf, 2018). However, the future of the agriculture sector is fundamentally tied to the better management of natural resources (The World Bank, 2008, 2017) and reducing the gap in age, gender, and technology involved with agriculture. Furthermore, reliable and sustainable agricultural production systems assure the reliability of the agriculture production systems and improvement of the farmers' output production.

Within the agriculture sector, livestock production has contributed towards the socio-economic development of smallholder farmers in developing countries (Mahanjana and Cronjé, 2000; Meissner, Scholtz and Palmer, 2013; Marandure, 2015). Although livestock production is mainly focused on the economic well-being of the farmer, in most developing countries people keep livestock for other off-farm expenses such as payment of lobola, school fees, insurance against emergencies and purchase of food (Kosgey et al., 2008; Thornton, 2010; Cholo, Oluwatayo and Chaminuka, 2017). However, whilst the livestock sector presents economic opportunities, its increasing pressure on the environment and natural resources must not be neglected (Rust and Rust, 2013). Moreover, robust economic development, rapid urbanization, and climate change are some of the drivers towards an increase in the demand for livestock products (Thornton, 2010). Climate change conditions like low rainfall and high temperatures have caused other commercial farmers to reduce their amount of livestock (Mdungela, Bahta and Jordaan, 2017), hence making smallholder livestock farmers become important participants in confronting food insecurity and poverty issues in developing countries (Molotsi, 2017). Previous research shows that in countries where there is limited arable land, farmers practice livestock farming more than crop farming (Kosgey et al. 2006;2008). Additionally, Statistics South Africa, (2017) reported that in 2016 household statistics, almost 53% of South Africa smallholder farmer households were involved in livestock production. Therefore, in order to mitigate the challenges affecting smallholder livestock production in developing countries, science and technology need to be integrated using participatory and interdisciplinary approaches in livestock production.

Researchers for the past decades have been dealing with issues on how to increase productivity in livestock production but with a lower environmental footprint productivity per animal (Herrero et al., 2015). However, the smallholder farmers face different challenges which include diseases, lack of adoption to modern technologies and insufficient resources and these are problems that create serious limitations to smallholder livestock production in developing countries (Kosgey et al., 2006, 2008). Moreover, climate change, poor livestock production and management systems have called for most farmers to adapt to new modern and sustainable technologies. Hence, this shows the need for smallholder livestock farmers to have accurate pedigree and animal performance records that assist with selection of correct animal genotype records to be matched with the environment (Scholtz et al., 2011). The integration of Information and Communication Technologies (ICTs) into smallholder sheep farming systems is facing different challenges and constraints which include poor ICT skills, poor level of awareness, financial constraints and inadequate power supply (Tijjani, Anaeto and Emerhirhi, 2017). Therefore, the change in technology needs to adapt to separate types of smallholder farming systems, adapting in a way that satisfies the dynamic expectations and requirements of the society, economy, and environment (Burgess et al., 2006; The World Bank, 2008).

Information and communication technology use in agriculture and rural development has surged in the past decade. Although ICT use in agriculture in developing countries is still growing, especially the use of ICT by smallholder farmers (Conradie, 2003; Irungu, Mbugua and Muia, 2015; Msavange, 2015). There are still few studies that prove how ICTs usage have impacted lives of rural people livelihoods such as Rahman & Mamun (2017), Soffer & Raban (2006), Krutkowski (2017) and Telecommunication & Report (2010). According to these studies, ICTs have managed to assist farmers with accessing financial services, manage the limited time they have by exchanging information without needing to move, increase in awareness, and to reach out to customers cost-effectively. Generally, the internet has overwhelmingly reshaped the way farmers use and disseminate their information. The future of agriculture development depends on how successful the information and knowledge produced is communicated and utilised (Mwanga, Simba and Yonah, 2014; Beheraa et al., 2015). Previous studies reported that in most developing countries, the use of cell phones is growing so fast and it has helped in improving communication between smallholder farmers and other stakeholders (The World Bank, 2011; Palmer, 2012). Web-applications like Facebook, Twitter and WhatsApp can go beyond the problems of farm management requirements of smallholder livestock farmers (Irungu, Mbugua and Muia, 2015).

Low offtake rate, diseases and poor recordkeeping methods have caused a decline in small ruminant production amongst smallholder farmers in most developing countries (Kosgey et al., 2006). Recordkeeping is the task of capturing, recording and storing of data to provide information necessary to make informed farm management decisions. Moreover, inbreeding problems and uncontrolled mating are major concerns within smallholder sheep farmers in developing countries (Kosgey et al., 2008; Thornton, 2010; Bedhiaf, 2018). After undertaking a case study in Tanzania on ICT as a tool for improving information flow among livestock stakeholders,

Mwanga et al. (2014) showed that current recording and recordkeeping systems were inadequate, affecting the quality of service received from extension officers. The author further reported that keeping of animal and farm records is a vital aspect in delivering extension services to smallholder farmers. Additionally, Abegaz et al. (2008) highlighted that livestock and farm records are essential in assessing and improving livestock performance within a farming system. Literature shows that there have been strategies implemented to improve small ruminant production for smallholder livestock farmers in developing countries (Kosgey et al., 2006, 2008, Herrero et al., 2014, 2015), but only limited studies were on the use, adoption, utilization and benefits of ICT in smallholder small ruminant production systems (The World Bank, 2011). However, the use of ICT in developing countries is still in need of better infrastructure to support the integration of ICT with agriculture (Conradie, 2003).

Information and communication technologies has shown positive trends in improving the livelihoods and socio-economic development of the livelihoods of the people as farmers have managed to improve communication with other stakeholders (Beuermann, 2011; Irungu, Mbugua and Muia, 2015). The ability of commercial farmers to select breeds with better reproduction, improved growth, meat and wool traits make them have an advantage over smallholder livestock farmers (Molotsi, Dube, et al., 2017). In developing countries, the indigenous livestock breeds are a valuable source of genetic material to smallholder livestock farmers (Kunene, Bezuidenhout and Nsahlai, 2009). Many studies including Kunene et al. (2009), Udo et al. (2011); Molotsi et al. (2017); Kosgey et al. (2008); Adesehinwa & Okunlola (2000) recommended that indigenous breeds can adapt to local and harsh environments, feed shortages, pests, and diseases and in doing so, the studies suggest that focusing on developing resilience within smallholder livestock farming systems is a justifiable purpose. Information and communication technology used as a tool for recordkeeping have the ability to reduce excessive use of paper when taking records (Abegaz et al., 2008), since manual data capturing is time-consuming and very tedious. After a study on the viability of pedigree recording and genetic selection in village sheep flocks of smallholder farmers in Ethiopia, Gizaw, Goshme, et al.(2014), showed that pedigree and performance recording is vital for improvement of smallholder livestock production. Therefore, it is the aim of this study to contribute to the use of ICTs by smallholder livestock farmers to keep proper records to perform analysis such as evaluating and improving livestock performance. Furthermore, to explore the sustainability of a recordkeeping database tool for livestock and farm management in smallholder livestock farming systems. A recordkeeping database system according to Abegaz et al., (2008) should:

- Be easy to use, implement, record, store livestock and farm production information.
- Assist with the selection and identification of the best, poor and worst management practices.
- Provide information relevant to make informed farm and livestock management decision.
- Assist with livestock performance evaluation such as comparing livestock in the same flock in terms of reproduction and production performance.

1.2 Problem Statement

The insufficient attention given to the smallholder sheep farmers and lack of proper exploitation of favourable reproduction and disease resistance traits amongst the indigenous sheep breeds are some of the obstacles hindering improvement of sheep production (Grobler, 2010; Molotsi, Dube, et al., 2017; Molotsi, Taylor, et al., 2017). However, despite notable strategies applied to improve smallholder sheep production, the farmers still incur difficulties with low offtake rates, diseases and low production performance (Kosgey et al., 2006). In order to meet the requirements of sustainable development goals (SDGs), previous studies have highlighted the significance of smallholder livestock farming. Studies which were done by Kosgey et al. (2008); Mahanjana & Cronjé (2000); Bowell. (2013) identified the lack of smallholder farmer's involvement in programs to improve production and management within smallholder farming systems as another factor adding to low production and poor animal performance. The failure to confront some of these challenges is due to the insufficient attention given to the smallholder farmers involved with sheep farming in most developing countries (Kosgey et al., 2008; Chima and Bowell, 2013).

Reliable data and reliable farming information will substantiate a sustainable way of sheep farming practice amongst smallholder farmers in developing countries. One of the goals of Science, Technology and Innovation in Africa is to improve the STI status in terms of technical competence, enabling environment, and technological innovation. In addition, engagement with different stakeholders is relevant in order to improve livestock production within smallholder livestock farmers in South Africa through integrating ICT with agriculture. However, recordkeeping is a fundamental link to the success of any business; good decisions emanate from good, reliable, and well-documented information. Mahanjana & Cronjé (2000) identified the lack of adequate management, planned breeding and recordkeeping as several factors affecting the smallholder ruminant farmers in the Eastern Cape area. The author further identified the lack of knowledge, education and time as reasons for lack of participation of some smallholder livestock farmers in recordkeeping. However, the farmers who are still using traditional recordkeeping methods or not at all, are at risk of encountering challenges and limitations affecting the smallholder livestock farmers in developing countries (Thornton, 2010; Mapiye, 2017; Bedhiaf, 2018; Makini et al., 2018).

Recordkeeping will not only help a farmer by ensuring traceability and keeping track of costs but also make information available for a quick reaction to changing circumstances. Moreover, to confront some of these challenges, smallholder farmers need tools that can assist them in complex decision-making, farm management marketing information and production methods (Thornton, 2010). However, it is not advisable for farmers to talk about profits and losses from intuition or guessing but rather from data derived from record books or any medium of recordkeeping a farmer can use and implement. Regular and efficient recordkeeping by farmers can be a central indicator of modern day agriculture. Although, the manner of recordkeeping is not consistent amongst smallholder livestock farmers in developing countries and varies from traditional to modern

(Mahanjana and Cronjé, 2000; Chima and Bowell, 2013; Ambrosino, Chandler and Todd, 2014). Smallholder sheep farmers in South Africa are expected to encounter same problems affecting smallholder farmers in developing countries (Mahanjana and Cronjé, 2000; Kosgey et al., 2008; Rege et al., 2011). Further, severe climate change conditions can lead to livestock failure when farmers are not able to take preventive steps due to lack of reliable weather forecast information (The World Bank, 2017).

The application of ICT tools such as mobile smartphones applications in recordkeeping can assist smallholder farmers to improve their capability to address the challenges and limitations they encounter (Sife, 2010; Lantzos, 2013; Mapiye, 2017). The use of a web-based application in other developing countries has allowed farmers to increase their production (Irungu et al. 2015). An application like iCow a web-based application has allowed its users (cattle farmers) to increase their milk production (The World Bank, 2011; Palmer, 2012); the application assist farmers with registering their cows and insemination date. The service also informs farmers with vital tips and information about breeding, nutrition and milk production efficiency by means of an SMS on weekly basis (Oafrica.com, 2012; Irungu, Mbugua and Muia, 2015). Inbreeding problems and uncontrolled mating are major concerns within smallholder sheep farmers and this is mainly due to poor management and animal identification practices which have affected the genetic improvement methods practiced within sheep farmers (Kosgey et al., 2008; Thornton, 2010; Bedhiaf, 2018). Transfer of information is cheaper and less time consuming with the use of information and communication technology. Engagement with different stakeholders is relevant in order to improve livestock production within smallholder livestock farmers in South Africa through integrating ICT with agriculture.

1.3 Rationale of Study

Smallholder livestock farmers play a key role in challenging food insecurity and poverty problems for the majority of the poor in developing countries (Kosgey et al., 2008; Thornton, 2010; Chima and Bowell, 2013; Molotsi, 2017). In South Africa, sheep production contributes substantially to the mitigation of poverty and food insecurity of many farmers in the smallholder sector in the Western Cape (Molotsi, 2017). The need for this study stems from the fundamental role that sheep plays in the livelihoods of smallholder farmers in South Africa. Smallholder farmers want to be more productive and prosper but have limited skills and information to make sound and proper decisions to improve production and especially, reproduction methods (Kosgey et al., 2008; Mapiye et al., 2009). The use of information and communication technology tools such as smartphones has contributed towards the improvement of smallholder farmers livelihoods in both developed and developing countries by creating new opportunities for farm management applications in small farms (Lantzos, 2013; Msavange, 2015; Pade, 2015; Masuka et al., 2016). In addition, the use of ICT has provided rural households with fast, reliable and easy modes of communication (Conradie, 2003; Sife, 2010).

There are unlimited recommendations as to what is crucial for improving the sustainable production of livestock and profitable smallholder livestock production (Thornton, 2010). The smallholder farmers can achieve such improvements through good farm management practices and improved recordkeeping techniques. The use of smartphone technology can overlap the difficulties of farm management requirements that have been a barrier for many years. Commercial farms have the ability to invest in new technology. In such cases, their farming processes are more efficient due to improved data management and recordkeeping that allows these farmers to track almost all their investments and working practices on and off the farm (Lantzos, 2013). Rural South African smallholder farmers play a role in mitigating poverty and food insecurity, the use of information and communication technology by smallholder livestock farmers can be used to improve the quality of decision they make (Molefe, Thamaga-chitja and Yobo, 2008). Moreover, information and communication technology can be a useful tool in collecting and combining local and traditional livestock farming knowledge by bringing together smallholder livestock farmers.

The documenting of animal records/pedigree through a web-application, which are performance and production records will assist the farmers in characterizing/selecting livestock and livestock farming systems that are resilient to the adverse effects of climate change. Furthermore, this can be achieved by the proper characterization of indigenous breeds in terms of their production and reproduction performances (Mdungela et al. 2017; Molotsi et al. 2017a). The information includes the performance record of livestock, type of breed, weight, and farmer's socio-economic conditions; this will help in traceability at the level of an individual farm. In addition, the use of ICT will provide opportunities for farmers to engage. There is potential for smallholder livestock farmer's improvement through integrating agriculture with ICT. The web application promotes accurate recordkeeping, improved service by reducing paperwork and human error. Unlike the traditional recordkeeping methods, ICT provides a more scientific, robust method of recordkeeping and minimizes asymmetric information flow. The database can support a farmer's decision-making. The study will also focus on characterizing indigenous breeds in terms of reproduction and production factors and this will allow farmers to understand the genetic diversity of their sheep populations. This will also allow farmers to select the animals with the best adaptive and high production traits and improve their sheep offtake rates.

1.4 Research Objectives

The main objective of this study is to evaluate the need of the integration of information and communication technology to develop a recordkeeping database of smallholder sheep farming systems in the Western Cape Province, South Africa and justify the use of a web application in recordkeeping.

The specific objectives of the study were:

1. To identify challenges and the benefits associated with manual data capturing and integrating ICTs in the management of data and recordkeeping by smallholder sheep farmers in the Western Cape Province.
2. To assess the smallholder's perceptions and willingness to support the web application additional development in South Africa.
3. To describe the input factors necessary to develop a web application for recordkeeping by smallholder sheep farmers in the Western Cape.

1.5 Study Questions

1. What are the perceived challenges associated with manual data capturing and methods used for recordkeeping by smallholder sheep farmers in the Western Cape Province?
2. What are the benefits and the challenges of integrating ICTs in the management of data and recordkeeping by smallholder sheep farmers in the Western Cape Province?
3. How do South African smallholder sheep farmers perceive the use of tools like the web application for recordkeeping and data capturing?
4. What factors determine the use of a web application for recordkeeping by smallholder sheep farmers in the Western Cape Province?

1.6 Research Outline

This thesis consists of five chapters, Chapter1 gives the research aims and objective, Chapter 2 gives an overview of the literature associated with the study. Chapter 3 and Chapter 4 consists of the results obtained from this study. In these chapters, farmers identified some of the challenges and benefits within smallholder sheep farming systems, their mode of communication, source of information and the benefits of the current recordkeeping methods. Chapter 5 provides the information on development of the web-application as well as the general layout of the application, which is still under development.

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Chapter 2 Literature Review

2.1. Background

Livestock production plays a substantial role in the social and economic uplifting of smallholder farmers in both developed and developing countries (Meissner et al. 2013). Moreover, previous research has established that globally, the livestock sector directly contributes to the sustenance of more than 600 million poor smallholder farmers in developing countries (Thornton 2010; Swanepoel 2008). However, reliable and quality information is vital for sustainable livestock production and improvement of farm management in smallholder livestock farming systems (Kirk et al. 2011; The World Bank 2011). Zhang et al. (2016) reported that with easy access to information and knowledge, farmers could improve their farm management and production skills in dealing with natural disasters, diseases, pests, transport, exchange of goods and marketing. However, in most developing countries smallholder farmers still rely heavily on information from extension officers (Molefe et al. 2008; Mapiye 2017; Mdungela et al. 2017). Additionally, studies by Munyua, (2007) and Consolata, (2017) reported that the number of extension officers available to assist farmers does not equal the number of farmers available and, this in turn, makes it difficult for farmers to consult extension officers in times of emergencies and difficulties.

Adoption of new technologies like Information and Communication Technologies (ICTs) in developing countries can be a useful tool in collecting, combining and sharing local and traditional livestock farming knowledge between farmers and other stakeholders (The World Bank 2011; Singh et al. 2015; Zhang et al. 2016). Kumar, (2012), defines ICTs as the technology for collecting, storing and processing of data and information using any ICT application such as computers or mobile phones and further include internet connectivity, online chatting and media technology. Nevertheless, although ICTs seem to have many benefits for farmers in developing and developed countries, evidence from the literature suggests that in developing countries, the high percentage of these tools have failed to fulfil users' expectations and therefore they are not extensively used by farmers (Conradie 2003; Bell 2016; Braimok 2017). Some of the factors found to be influencing how livestock producers react to innovations and inventions have been farmers can only adapt to these ideas in livestock production if they meet the priorities, needs and resources of the farmers (Udo et al. 2011; Palmer 2012). However, Mapiye (2017) found that stakeholders need to explore the ability of smallholder livestock farmers to invent, share, record and communicate their own intervention/extension messages for the problems they encounter, mitigate and solve. The author further suggest that a management database system is an example of such tools that will empower farmers to take a lead role in the creation and documentation of information which includes livestock breeds, livestock pedigree information and also other important farm activities. A management database system is an application or software that manages the recording, storing, recovering and updating of information.

In order to mitigate and confront challenges affecting smallholder livestock production in developing countries, science and technology need to be integrated using participatory and interdisciplinary approaches. This allows farmers to add input to the strategies and programmes implemented to improve smallholder livestock production in developing countries (Kosgey et al. 2006; 2008). After studying the farms in Bindura, a district in Mashonaland central province, Zimbabwe, Chisango, (2017) reported that farmers from both farms specified that physical method of capturing data and recordkeeping using a pen and paper on the farm is monotonous and time-consuming. However, the key implication drawn from this is that farmers keep written records of their farm management and most are not well organised and not easily traced back and compared to previous and current farming year's data (Lantzos 2013). Existing research, however, identifies the critical role of good recording of smallholder livestock production information for the improvement of selecting livestock for specific genetic traits and production performance (Molotsi 2017; Abegaz et al. 2008).

Scholarly publications on smallholder livestock production show the importance of a formal recordkeeping system for smallholder sheep farmers in South Africa (Mapiye 2017; Molotsi, Dube, et al. 2017). Recordkeeping according to Abegaz et al. (2008) is an important aspect of good farm and livestock management that involves the recording of livestock performance records and performing other vital farm and livestock management functions. These records are stored in a central management database where records are stored and kept for future reference and analysis for sustainable livestock production (Mapiye 2017). However, there is no proper recordkeeping system prepared for smallholder livestock farmers in developing countries and this affects the improvement of livestock performance and sustainable livestock production (Kosgey et al. 2006; 2008; Molotsi 2017). Furthermore, climate change has affected the ability to improve smallholder livestock production, especially its impact on the availability of natural resources like water, land, and plants (Herrero et al. 2010; Rust & Rust 2013). Therefore, successful and sustainable improvement of smallholder livestock production in developing countries depends on livestock identification, recording, storing, and keeping of consistent animal records (Gizaw, Goshme, et al. 2014). However, previous studies have identified that smallholder farmers do not perform these tasks and most fail to take a regular measurement of livestock performance (Mahanjana & Cronjé 2000; Mapiye et al. 2009; Gizaw, Haile, et al. 2014).

Recordkeeping is necessary to the improvement of sustainable livestock production of smallholder farmers in developing countries (Gizaw, Goshme, et al. 2014). Farmers are able to add, edit and store livestock information. Moreover, Abegaz et al. (2008) reported that genetics and the environment are the two major factors for defining how an animal performs. However, researchers for the past decades have been dealing with issues on how to increase productivity in livestock production but with a lower environmental footprint productivity per animal (Herrero et al. 2015). After the study in KwaZulu-Natal, South Africa, Kunene et al. (2009) indicated that indigenous livestock breeds are a valuable source of genetic material to smallholder livestock farmers. Many studies including Kunene et al. (2009), Udo et al. (2011); Molotsi et al. (2017); Kosgey et al. (2008); Adesehinwa & Okunlola (2000) recommended that indigenous breeds can adapt to local

and harsh environments, feed shortages, pests, and diseases and in doing so, the studies suggest that focusing on developing resilience within smallholder sheep farming systems is a justifiable purpose.

The ability of commercial farmers to select breeds with better reproduction, improved growth, meat and wool traits make them have an advantage over smallholder livestock farmers (Molotsi, et al., 2017a). However, the indigenous sheep breeds used in smallholder livestock production have better fitness, survival and tick resistance traits when compared to commercial breeds (Kunene et al. 2009; Molotsi 2017). However, the performance of these breeds is uncharacterized in terms of production and reproduction within the smallholder sheep production (Molotsi 2017). The characterization of such breeds using recordkeeping/management database tools will lead to the improvement of smallholder sheep farming systems (Makini et al. 2018; Chima and Bowell 2013). Smallholder livestock farmers should focus more on performance recording as cases of inbreeding can impair growth, production health, fertility and survival of livestock (Rege et al. 2011; Ojango et al. 2016). Inbreeding is the mating of animals with a close genetic relationship to produce an offspring and this is due to lack of control of flocks mixed in the fields and at water drinking points (Ojango et al. 2016). This kind of approach will assist smallholder sheep farmers with selecting flocks that are resilient to the effects of climate change and have better production and reproduction traits.

Great potentials exist for small ruminant production; hence, the farmers must get a comprehensive extension education to achieve these potentials. Molotsi, (2017) states that there is unknown genetic diversity of smallholder sheep populations in Africa and using solely traditional breeding has limited impact on smallholder sheep production. However, this is significant because it justifies an investigation on the current study on recordkeeping within smallholder sheep farming systems. Moreover, on how the use of ICT tools like the recordkeeping database can assist smallholder sheep farmers in developing countries with obtaining significant pedigree information for selecting breeds that have better production and reproduction traits. Smallholder livestock farmers are confronted by a number of challenges such as low sheep offtake rate, poor production, and growth performance (Kosgey et al. 2008; Pollott & Wilson 2009; Ojango et al. 2016; Molotsi 2017). In addition, this shows the need for smallholder sheep farmers to have accurate pedigree records that allow farmers to be able to match the environment with the correct animal genotype records to ensure increased and sustainable animal production (Scholtz et al. 2011).

The integration of ICTs into smallholder sheep farming systems is facing different challenges and constraints which include lack of ICT skills, low level of awareness, financial constraints and power cuts (Tijjani et al. 2017). Moreover, Sife (2010) makes the very valid point that despite the increasing recognition of the potential of ICTs tools in reducing poverty and improving rural livelihoods, there are still divergent views over the extent, nature and scope of their contribution. This justifies an investigation on the current adoption, usage, and benefits of ICTs tools in smallholder sheep production. The review will discuss and define the role of ICTs in agriculture and smallholder farming systems with particular reference to livestock production systems. It is

therefore important to investigate the level of adoption, usage, and benefits and update existing knowledge on the matter. This section reviews the application of ICT (management database) in agriculture in general with more focus on sustainable livestock production, and explore the integration of ICTs with the smallholder sheep farming system. The review also provides an overview of the use, benefits and challenges of using ICT tools for improving livestock farming.

2.2. Information and communication technologies (ICTs) and Agriculture

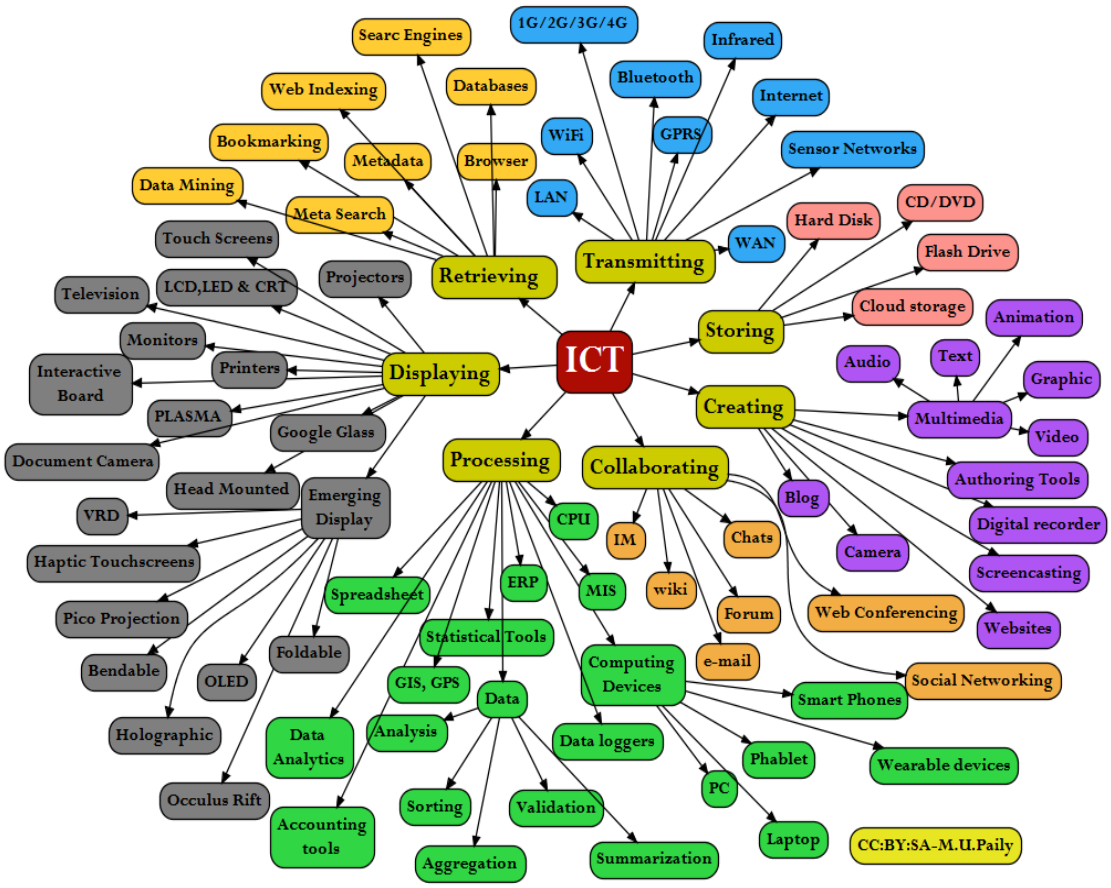
The exchange of information and communication continues to be an important factor in agriculture (The World Bank 2011; Van Zyl et al. 2014). This exchange of information was vital ever since people started growing crops, trees, keeping livestock and catching fish. However, according to The World Bank (2011), poor farmers face challenges to communicate, inform and acquire information for improving productivity even if they encounter similar problems year after year. Despite poor production being one of the main factors hindering economic growth in many developing countries (Cirera et al. 2016). The use of updated and reliable information allows these farmers to manage and address these challenges and ICTs play a major role in assisting farmers in addressing these challenges (Van Zyl et al. 2014). Personal ICT devices such as mobile phones or tablet PCs are becoming more widely available, and they are increasingly becoming the technology of choice for delivery of ICT services and solutions (Sife 2010; Van Zyl et al. 2014; Msavange 2015). Having the correct farm information at the correct time allows smallholder farmers to make proper and better decisions. Furthermore, Maru (2018) states that data-driven agriculture assists farmers with adapting to or mitigate the effect of climate change, reduce risks of pests, diseases, and improve resilience in agriculture. However, improving resilience of crops or livestock is vital for the subsistence of families, communities and nations (Mdungela et al. 2017).

Globally, more than 500 million smallholder farmers play a significant role in food production and genetic diversity of food supply (World Resources Institute 2013; The World Bank 2017). Therefore, the application of ICT to the agriculture industry presents the perfect opportunity for economic growth, poverty alleviation, and sustainability amongst the smallholder farmers (Van Zyl et al. 2014; Palmer 2012; Bell 2016). The use of ICTs such as mobile technology and remote-data sensing are changing the manner in which smallholders have been farming with more focus on producing more whilst sustainably managing natural resources (Maru 2018). The use of ICTs in agriculture has managed to assist farmers to access and share information and data to and from different stakeholders in the agriculture industry (Palmer 2012; Irungu et al. 2015; The World Bank 2011). As the management of farmer information and data becomes the norm, the farmer becomes one of the many sources of data, information and one of the users of the information. Van Zyl et al., (2014) suggests that ICTs have the potential to transform economic growth in Africa due to common challenges most farmers in developing countries encounter. These challenges include high production and transportation cost, poor access to new technologies, poor infrastructure, unfavourable market conditions, poor informal recordkeeping

methods, and natural disasters caused by climate change. Existing research recognises the effects of asymmetrical information flow and supports an equal sharing of data and information in agriculture by smallholder farmers and other stakeholders (The World Bank 2017; The World Bank 2011; Palmer 2012).

2.2.1. What is ICT in Agriculture?

Referring to Margaret et al. (2018) and the report by Salampasis and Theodoridis, (2013), the definition of ICT shows that there is a wide range of ICT tools and services which can assist farmers to improve production, farm management and any other agriculture-related process. Kumar, (2012) further defines ICT as the technology involved in collecting, storing and processing of data and information using any ICT application such as computers or mobile phones and further include internet connectivity, online chatting and media technology.



Source: Margaret et al. (2018)

Figure 2.1: The diagrammatical representation of what is ICT in a broader context

A more in-depth definition is given by the published work of the World Bank division (The World Bank 2011). ICTs can improve the agriculture sector of both developing and developed countries by offering reliable and

valuable answers to many of the problems the sector is currently facing (The World Bank 2011). Information and communication are both important features in improving agriculture production. The use of ICTs in recordkeeping of agriculture information has become a fundamental tool in attaining better productivity and sustainable production. Moreover, farmers are able to plan and prepare for any trends and drivers of agriculture production in developing and developed countries (Kumar 2012). There are a number of stakeholders involved in agriculture development process. Their knowledge inputs and requirements differ and the use of ICT tools such as mobile phones in agriculture has managed to close this gap (Irungu et al. 2015). However, there is challenges on the dissemination of ICT related projects to most smallholder farmers and classifying of sustainable agriculture business models in developing countries.

Agricultural insurance is becoming very important as harsh weather patterns generated by climate change are intensifying instability in livestock food production and prices (Van Zyl et al. 2014). Insurance of livestock or crops in developing countries against weather uncertainties by smallholder farmers has been limited and several studies were done on the effects and impacts of climate change in both livestock and crop production (Herrero et al. 2015; Rust & Rust 2013; Rege et al. 2011). ICTs can play a major role in the livestock or crop insurance such as protection against risks by enabling farmers to have access to information and services from different stakeholders, providing information about weather and market price situations, providing better services and facilitating fast communication between stakeholders (Van Zyl et al. 2014; The World Bank 2011). Employing ICTs in the framework of agriculture offers a lot of potential for both the farmers and extension services in rural development. Other studies have also shown positive impacts when using ICT tools on rural livelihoods and farmers in agriculture (Sife 2010; Irungu et al. 2015; Msavange 2015; The World Bank 2011; Conradie 2003). As listed by The World Bank, (2011) the five main trends that have been the key drivers of ICT in agriculture especially for resource-poor farmers are as follows:

1. There is a decrease in the cost of ICT tools as seen by the increase in mobile phone users in developing countries and development of Telecentre infrastructures.
2. The introduction of innovations that are adaptable and affordable such as mobile-based applications.
3. The importance of sharing knowledge, exchanging data and the ability to access data remotely. In addition, sharing of knowledge and data have formed opportunities to involve more stakeholders.
4. The growing interest from the private sector has enhanced the access, affordability and adaptability of ICTs for agricultural development.
5. The change in information accessibility, including the open access movement where many government and organizations are targeting to make data like research findings openly available to the public and social media platforms which are being used for sharing knowledge and collaboration in agriculture.

2.3.1. Application of ICTs in Agriculture

The capability of ICT tools to support and enhance the access to and exchange of information for smallholder farmers is clear (The World Bank 2011). Moreover, ICTs have managed to improve networking among the stakeholders involved in the agriculture sector. Previous studies by Irungu et al. (2015) ; Msavange, (2015); Masuka et al., (2016); Tijjani, Anaeto and Emerhirhi, (2017) did conclude that the use of mobile phones in agriculture reduces transaction costs, improves communication and illiteracy rate within smallholder farmers in developing countries. In addition, Kirk et al., (2011) state that the significant boost to farmers revenue will come from the use of mobile phones. The use of services like mobile payment systems, mobile information services and helpline services have managed to assist farmers in developing countries with access to critical information on market prices, changes in temperature, rainfall, cash payment and disease outbreaks (Irungu et al. 2015; The World Bank 2011; Kirk et al. 2011) . An example of the application of ICTs in agriculture is the Esoko Ghana Commodity Index (EGCI), which make use of mobile technology to circulate market prices for agricultural commodities, weather information and for data collection on/off the farm (Van Zyl et al. 2014). The application of ICT has also transformed the knowledge of farm management and planning of land-use (Kumar 2012). A farmer is able to have access to information about climate features, soil, plants, and vegetation. Further findings of the literature regarding ICT use in agriculture suggest that for smallholder farmers to gain and overcome the challenges of farming, ICT use in agriculture must aim at symmetry flow in information in its use among all players and stakeholders (Van Zyl et al. 2014; Maru, 2018).

A considerable amount of literature on ICTs used in agriculture has identified the following areas in which ICTs is being utilised and implemented (The World Bank 2011; Maru 2018; Bell 2016; Van Zyl et al. 2014):

1. Widening farmers access to equitable markets, global competitiveness and sustainable resource management
2. Improving crop, livestock and fish production through strengthening the participation of farmers, institutions, governments, private and public sectors.
3. Agricultural innovations such as smartphone technology like FarmManager (Lantzos 2013).

2.3.1.1. Land and Water Management

The main aim of better farm management is to improve farm production and maintain the biodiversity of the farm whilst reducing adverse environmental impacts (The World Bank 2008; Munyua 2007). According to The World Bank (2011), major natural resource constraints and adverse effects of climate change are making it more significant for developing countries to develop rigorous land and water-use policies, effective, and well-supervised irrigation systems. Several studies have concluded that the use of ICTs has managed to assist farmers with knowledge on how to sustainably manage their land, environment, and water (Oladele 2015; Kirk et al. 2011). The livelihoods of small-scale farmers depend on the conservation of these natural resources

(Mdungela et al. 2017). Reliable information can significantly improve the quality of decision-making in land and water management (Pade 2015; Ojango et al. 2016). The development of tools such as geo-informatics technologies has managed to assist various agriculture stakeholders with predicting any natural disasters like floods and storms (Kumar 2012). According to Kumar (2012), geo-informatics are more helpful in precision farming where more interest is given to micro level entities such as soil type and quality, the environment of the area, management of a specific site, and variability of vegetation within the area.

The ability of ICTs to make information available for smallholder farmers allows better scheduling and planning of land and water use. ICTs have tremendously supported reliable management/control in land use and administration by enabling open and transparent access to land records for all (The World Bank 2011). Munyua (2007) suggests that farmers need to be included in the process of land, water, and environmental management via innovative and participatory methods because land and water management aims at improving livelihoods, agro and natural-ecosystem resilience, agricultural production and environmental services. Despite attempts to tap water resources and adapt to climate change, ICTs can prevent and reduce losses in agriculture through well-organized and documented weather information, along with better irrigation management systems, which are more important in agriculture than ever (Kirk et al. 2011; The World Bank 2011). The challenges of not managing natural resources well include water shortage, poor water quality, river siltation, deforestation, overgrazing, overuse of resources, loss of biodiversity, land degradation, and others. This, in turn, has affected the agriculture production, Van Zyl et al. (2014), concluded that globally using good production techniques can increase the efficiency and profitability of crop and livestock production. In South Africa, efficient irrigation practices have managed to mitigate effects of long dry periods of drought, and effective utilization of ICT has a positive effect on irrigation efficiency (Van Zyl et al. 2014).

In order to protect and conserve the natural resources, farmers in South Africa according to the work published by van Zyl et al. (2014) in partnership with the GenARDIS used GIS applications in the management of the Rooibos tea lands and in exploring the dynamics of gender and age in rural areas. Precision agriculture provides a sustainable and efficient system for the sustainable use of natural resources (Swinton & Lowenberg-Deboer 2001). In addition, ICT can support the entire life cycle of land reform such as the analysis of reallocation options to the provision of land registration (The World Bank 2011).

2.3.1.2. Plant, Crop and Animal Production Management

In developing countries, agricultural extension services such as extension officers are the most used method of acquiring information on crop and livestock production (Stilwell & van Rooyen 1990; Molefe et al. 2008). Several studies argue that the number of extension officers available to help farmers especially the resource-poor farmers in developing countries does not tally equally well with the number of available smallholder farmers (Molefe et al. 2008; Mapiye et al. 2009). Using modern ICT tools like mobile phones in agriculture have managed to improve various facets of agriculture production, research, and education, and are playing a

vital role in disease control, exchange of information, management, productivity and marketing of crops and livestock production (Irungu et al. 2015; Cirera et al. 2016; Palmer 2012). ICT tools offer new ways of providing services to farmers especially women and they make it easier and cheaper for these farmers to reach out to different stakeholders (Braimok 2017). Exchange of agricultural information on inputs, markets, and management through ICTs tools like mobile phones, minimise the need for travel and visits by extension officers (Munyua 2007). According to The World Bank (2011), ICT tools guarantee that farmers exchange and access information quicker and easier, without having to rely only on extension officers.

An example of a successful initiative utilizing ICTs to offer extension services and training to small-scale farmers is the Digital Doorways Computer stations in Limpopo province, South Africa. These computers introduced by the Limpopo Department of Agriculture provide internet access to smallholder farmers in rural communities and farmers can access information quicker and easier (Fahrion et al. 2005). The use of ICT tools will help smallholder farmers to plant crops at the right time and select the best livestock breeds that can adapt to changes in different weather patterns (Munyua 2007). The sustainability of livestock and crop production goes hand in hand with the farmer's ability to produce from indigenous breeds. Indigenous livestock breeds can adapt to local environmental conditions. Moreover, the breeds are resistance to diseases and parasites, and the classification of such breeds is thus critically important (Molotsi, et al., 2017a). The application of ICT tools in recordkeeping at farm level assist farmers with the knowledge on the diversity of the characteristics the livestock breeds have in terms of adaptability, weight gain and production (Masuka et al. 2016; The World Bank 2011). The ability to identify different breeds, record and characterize the genetic diversity of animals, plants and crops offer an opportunity to develop and implement plans to ensure the utilization and protection of indigenous breeds and species.

2.3.1.3. Accessing Markets and Socio-Economic Development

Smallholder farmers in most developing countries face many challenges and problems owing to features like under-investment, poor access to markets and unfair market conditions, inadequate access to advanced technologies, low production, transport costs, and gender asymmetry (Treinen & Van der Elstraeten 2018; The World Bank 2017). According to Kirk et al., (2011), smallholder farmers in developing countries normally get unfair prices for their products because they have limited access to markets. Information and communication technology tools have created the potential to deliver diverse marketing information and promote access to markets for smallholder farmers especially information on market prices and demand (The World Bank 2011; Irungu et al. 2015). ICTs allows farmers to be aware of changing market conditions and price offers, and mobile-phones holds great promise in supplying this information, and other essential information responsible for the betterment of the socio-economic life of farmers (Van Zyl et al. 2014).

ICTs contribute positively to the socio-economic development of smallholder farmers in developing countries and improves the delivery of services, as they lower agricultural production costs (The World Bank 2011).

One example of such technology is the Esoko Ghana Commodity Index (EGCI), which aims at improving smallholder farmer's income in developing countries. EGCI is a communication platform that broadcasts a market price index of physical commodities on a weekly basis and it allows farmers to track wholesale and retail market prices (Consolata 2017). During the time of the study, the EGCI was active in ten countries and still continues to expand (Consolata 2017; The World Bank 2011). Mobile phone applications have impacted the farmers' choices on sources of market information and awareness of market conditions and price offers because the farmers have difficulties in identifying the best markets to sell produce as they often have difficulty discovering where and when they can purchase inputs (Masuka et al. 2016; Sife 2010; Van Zyl et al. 2014). In South Africa, an example of such tools is ABALOBI, which is a mobile application suite and a programme aimed at promoting social justice and poverty alleviation in the small-scale fisheries value chain by transforming the way fish farmers stakeholders produce knowledge, supervision of marine resources, and building resilience in the advent of climate change. The application promotes traceability, storied seafood by authorized small-scale fishers from hook to cook, in a way that is both ecologically responsible and socially fair (Abalobi 2017). In agriculture, mobile financial services have assisted smallholder farmers with access to services like savings and insurance services. Another example is the Vodafone's mobile money transfer service, M-PESA (Kirk et al. 2011). M-PESA is a mobile phone application that supports mobile phone-based money transfer, financing and microfinancing services to the rural poor in Kenya and other countries (Irungu et al. 2015; Kirk et al. 2011).

2.3. Types of ICT tools promoting agriculture production

Modern ICT tools allow different players in agriculture to communicate and exchange information with farming communities, access inputs, markets and improve agriculture production (The World Bank 2011). Rural farmers choose to use the combined tools, which include both modern and old devices because of their affordability. Rural farmers use various ICT tools when accessing information, according to Consolata, (2017) the examples of these technologies include; telephones, television, radio and the internet. These tools can be very useful in providing various types of information to the farmers. The author further categorizes the tools into three main categories namely; mobile phones, web-based communications, and radio/television.

2.3.2. Web-Based Communications

Globally, the use of web-based communications like e-mail, websites, online webinars and web-based applications are gradually becoming important for exchanging and disseminating agricultural information and knowledge, marketing of products and services. With reference to Munyua (2007), Africa was leading in mobile phone subscriptions and it has been increasing over the years as fast as the global market. In Africa, some of the programmes that use the web-based communications system to assist small-scale farmers with access to information, markets, credit, inputs and weather conditions are Foodnet in East and Central Africa,

Kenya Agriculture Commodity Exchange (KACE) in Kenya and Malawi Agriculture Commodity Exchange (MACE) in Malawi (Munyua 2007). Currently one of the main barriers causing poor adoption of ICTs in developing countries is the use of English language content. Most rural farmers do not use english language as their first home language and almost all web-based applications use the english as the language of the web contents (The World Bank 2011; Munyua 2007). The diversity of cultures and different needs in different countries have specific problems that need specific approaches, especially in developing countries. There is a need to develop the web to be widespread and useful for the majority of the people in the world (Consolata, 2017). Web-based communications such as e-mail serve similar purposes to those discussed in the next section for the telephone/mobile phone. High illiteracy, unreliable power supply, and cost of communications are a major barrier to widespread use (The World Bank 2011). In South Africa, there is a wide range of available mobile and web-based applications that are particularly useful to farmers operating in South Africa's agricultural sector. An example of such is the Cape Farm Mapper, which is an online maps platform that helps farmers with spatial information queries, environmental management and decision-making. It is an information-rich resource and is also used for the monitoring of other crops, such as wheat, potato and maize (Vienings 2016).

2.3.3. Radio and Television

According to Treinen and Van der Elstraeten, (2018), high illiteracy is one of the barriers to successfully implement and utilize ICTs in most developing countries. Recognizing the right tools of technologies that are appropriate to local needs is often a challenge (Treinen & Van der Elstraeten 2018). In Africa, for many smallholder farmers, radio is the only source of information outside the community (Consolata, 2017). Radio and television represent an effective answer for conveying agricultural production content, mostly in remote areas where there are poor infrastructure and lack of internet access (Telecommunication & Report 2010). They increase the effectiveness of programs for ICTs in agriculture that seek to assist different stakeholders. Radio is one of the most effective means of reaching to farmers in different places and occupations because of the readily available infrastructure of Radio and TV stations (The World Bank 2011). According to Irungu et al. (2015), youths in Kenya watched agricultural videos, TV programmes, listened to radio programmes to acquire accurate and useful information to enhance production and to compare different markets.

Access to information may be restricted due to social, cultural, economic and geographical factors, but ICTs, such as radio and television can overcome these and other restrictions by bringing the information to people both in close and remote areas (Telecommunication & Report 2010). The previous studies have concluded that radio is very important when targeting rural women, because of the ability of broadcasting a programme in local language and a radio is a medium that is accessible to all, literate or illiterate (Gray et al. 2006; Telecommunication 2010; Conradie 2003). Local radio programmes can reach a comprehensive audience through a single broadcast but some farmers prefer both visuals and audios. The farmers in Burkina Faso are

benefiting from a TV program which broadcasts monthly market prices and demands in different agricultural markets including the pricing information on grain and livestock (Munyua 2007).

2.3.4. Telephones/Mobile Phones

Advances in mobile phone technologies and internet connectivity have made progress in the globalization of agricultural markets, better exchange of information and improvement in agricultural production (Telecommunication & Report, 2010). There has been a major progress in improving communication and decision-making in developing countries especially rural areas because of the use of mobile phone technologies. Access to the right information at the right time supports farmers to make informed decisions. The previous studies have shown how farmers in different developing countries are profiting from the use of mobile phones in agriculture production and rural development. Kirk et al., (2011) identifies that there is no same barriers to access of mobile phones. Technology and mobile phones are becoming more user-friendly, economical and convenient to use.

Irungu et al. (2015) concluded that mobile phones have increased opportunities, motivated and increased the capacity of the youth to participate in agriculture targeting niche markets. Moreover, YouTube, Twitter and WhatsApp are some of the platforms the youths are using in accessing agricultural knowledge and information. One example of a mobile technology application is iCow (The World Bank, 2011); it is a mobile phone-based agricultural information platform for smallholder farmers and it is simple to use, cost-effective and reliable. It assists farmers with improving their capacity development and skills through augmented knowledge, and the exchange of information is in their language of choice (The World Bank, 2011). The use of mobile phones has the potential to alleviate some of the challenges and barriers of agriculture production and development (Sife, 2010; Palmer, 2012). The usage of mobile phones and telephones have made it easier for women to participate in agricultural activities (Soffer & Raban, 2006). Braimok, (2017) argues that ICT tools like mobiles and smartphones have managed to empower and develop human capacity through an innovative application such as WhatsApp. The author further indicated that the women in the study did not see the benefits of using the internet.

2.4. The role of ICTs in smallholder livestock production

Livestock production is important in developing countries, with the majority of the rural population in developing countries depending on it (Thornton 2010; Herrero et al. 2015). The resource-poor farmers face major challenges of increasing production in a state of diminishing natural resources needed for production. The increasing demand for livestock products, however, also offers opportunities for farmers to improve and sustain their livelihoods (Udo et al. 2011; Thornton 2010; Herrero et al. 2015). Consumers demand quality and food safety has put increased importance on the traceability of agricultural production (Van Zyl et al. 2014). Recording of information on animals and the farm allows the farmers or any other stakeholders to track a

product from its origin along the entire value chain. Information and communication technologies play an important role in addressing these challenges and uplifting the livelihoods of the rural poor (The World Bank 2011). For instance, improving competence, productivity and sustainability of small-scale farmers, information about animal breeds, genetic diversity, pest and disease control, improved markets need to be reliable and easy to understand (FA0 2003; Soffer & Raban 2006; Sife 2010; The World Bank 2017; Makini et al. 2018).

Agriculture is the backbone of most African economies and livestock production contribute largely towards the mitigation of poverty, food insecurity, unemployment and maintaining biodiversity (Mahanjana & Cronjé 2000; Mapiye 2017; Meissner et al. 2013). Reducing isolation, improving decision-making and better farm management using information and communication technologies can open up new opportunities and allow easier integration of smallholder farmers into national and global markets (Tijjani et al. 2017; The World Bank 2011; 2017). The role of ICTs in livestock production has been an important topic of study for the past years, and recent evidence has shown that. This is because of the rapidly changing livestock production systems, population growth and urbanization, environment and climate change, government policies and institutions (Udo et al. 2011; Herrero et al. 2010; 2015; Thornton 2010; Rust & Rust 2013). The availability of genetic diversity in smallholder livestock breeds can be a solution to adverse effects of climate change on livestock productivity (Scholtz et al. 2011) but the exclusion of farmers in programmes to improve their productivity can also be a challenge (Gizaw, Haile, et al. 2014). According to Scholtz et al. (2011), diverseness of animal breeds in smallholder livestock farmers will allow animal breeds to be matched according to their performances in different environments. The author further concluded that not all traits are equally important for improving productivity but for smallholder farmers to benefit from new technologies efficient recording of performance and pedigree records is necessary to reduce cases of inbreeding and to assist farmers in selecting animals adapted to a specific environment. This section will highlight the role of ICTs in livestock production and the importance of it in both developed and developing communities.

2.4.1. Educating Livestock Farmers

Farmers are the primary innovators in agriculture. Chisango, (2017), recommends that to increase the adoption and use of ICT in developing farming communities there is need for government to back the programme by means of establishing information centres to impart new technologies to local farmers and exchange of information. Exchange of information and data between farmers and other players in the livestock industry is important so that they can make better decisions to improve livestock production (Meena & Singh 2013). ICTs creates new opportunities for mobile applications like iCow and FarmManager to benefit smallholder livestock farmers (Lantzos 2013; Oafrica.com 2012). The use of a smartphone applications like M-Farm, iCow, and Esoko can overcome the challenges and difficulties of illiteracy, poor farm management and marketing that have been hindrances for many years so far (The World Bank 2011; Oafrica.com 2012). In countries like India and Kenya, ICTs have managed to create a platform for sharing weather information, market prices and disease

outbreaks via short media service (SMS) (Irungu et al. 2015; Masuka et al. 2016). In addition, these services have managed to reduce transaction costs by efficiently addressing farmers specific problems on time (Meena & Singh 2013).

Although ICTs has been and continues to be instrumental in livestock production, some studies have identified that most of the rural farmers face challenges of poor network coverage, power cuts, poor infrastructure, and language to fully utilize the opportunities of using ICT tools in livestock production (Meena & Singh 2013; The World Bank 2011; Van Zyl et al. 2014). According to Meena & Singh (2013), in South Africa, Senegal, Uganda, and other countries, ICTs have managed to reduce unemployment in rural communities, develop telecommunication and networking opportunities, and are a tool for distance training and education. Web-application like iCow can deliver SMS messages to farmers with information on how to improve production. According to The World Bank (2011); van Zyl et al. (2014), farmers using iCow increase their production, income, soil fertility and reduce livestock mortality and farmers can share their iCow messages and teach other farmers and communities. The farmers increase their general farming knowledge and find farming less risk. The development and use of ICTs have managed to reduce the isolation and marginalization of smallholder livestock farmers in developing countries. ICTs has assisted and accelerated the circulation of knowledge and information that is useful for the empowerment of people irrespective of sex, age, education and others (Soffer & Raban 2006; Tijjani et al. 2017; Braimok 2017).

2.4.2. Farm Management

Farm management is important in agriculture and is crucial to the improvement of livestock production among smallholder livestock farmers in developing countries. Moreover, the participation of smallholder livestock farmers in using ICT tools in livestock production is vital to success in productivity (Lekopanye & Sundaram 2017). ICTs have changed the way farmers' access and record information on improving livestock production. The application of ICT has transformed the knowledge of farm management amongst smallholder farmers in developing countries (The World Bank 2011). Farmers make decisions according to their immediate situations and they do so at every stage of the production (Maru 2018), using modern technology, farmers are able to record various traits of each animal, such as pedigree, reproduction, growth, health, feed conversion, age, and meat quality (Kumar et al. 2017). Some examples of the tools and applications that have been successful include iCow, Esoko and FarmManager (The World Bank, 2011).

Using the information recorded, farmers are able to improve production, decisions making and traceability on the farm (The World Bank 2011). Traceability in agriculture according to van Zyl et al. (2014), is the ability to track back the origin of a product from the information recorded from its origin to final destination in the whole value chain. Additionally, the increase in demand for quality and animal safety has positively influenced the need for traceability in the developed world markets. According to Kumar et al. (2017), some of the information recorded will include:

- Breeding (different type of breeds)
- Individual animal records, health
- Pedigree
- Herd size (number of males and females)
- Feeding, milking and selection/culling
- Task reminder
- Finances
- Reports and address book

2.4.2.1. Exchange of Information, Data and Communication

Kumar et al. (2017) defines ICT as an umbrella term that represent any technology that helps to find, utilize, store, and communicate information and it involves the use of computers and the internet. Ever since the day people started farming, farmers have continuously seek information and knowledge on how to improve production, livestock resilience and market access (The World Bank 2011). There is a significant increase in the number of use of ICT tools such as mobile phones and the internet (FAO 2007). The use of mobile phones in rural areas has managed to assist farmers with social and economic benefits whilst reducing the rural digital divide through promoting communication and exchange of information (The World Bank 2011; Meena & Singh 2013). WhatsApp is an example of such an application, farmers are able to share, communicate and exchange information via WhatsApp groups (Irungu et al. 2015). In most developing countries WhatsApp is the most used source of communicating and exchanging ideas, Irungu et al. (2015) recommended that adequate and proper utilisation of social media platforms has a direct impact on improving production and reducing gaps in livestock production such as age and gender.

2.4.2.2. Breeding

Development of livestock production among smallholder farmers in developing countries is affected by the lack of properly coordinated genetic improvement programs (Kosgey et al. 2006; Gizaw, Goshme, et al. 2014). The lack of proper breeding season, mating and the absence of genetic selection are a common feature within smallholder livestock-farming systems (Gizaw, Haile, et al. 2014), and as a result, smallholder livestock farmers are facing challenges such as low productivity, high mortality rate and low off-take rates (Kosgey et al. 2006; Mapiye et al. 2009). The evidence from the previous studies show that pedigree and performance recording is important to improve breeding of smallholder farmer's livestock in developing countries (Gizaw, Goshme, et al. 2014; Rege et al. 2011; Chisango 2017). Breeding according to Kumar et al. (2017), covers the information and data on the genetic diversity of the animal breeds and all features associated with animal behaviour, mating, feeding, pests, and diseases. The developments in ICT technology use in livestock breeding over the past few decades have managed to assist farmers in animal health and production management (The World Bank 2011). Using this information, the farmers are able to identify and select livestock that are

genetically superior breeds adaptable to the environment and harsh weather conditions. The study of Meena and Singh, (2013) concluded that the use of tools like mobile phones in recording reliable and accurate livestock pedigree and production information is helping in alleviating livestock disease and pests, promoting production, management and marketing of livestock products.

2.4.2.3. Livestock Health - Pests and Disease Control

Throughout the years, livestock health has always been vital for the subsistence of families, communities, and nations in the developing world (Swanepoel 2008; Mapiye et al. 2009; Udo et al. 2011). This is because of the social and economic importance of livestock among the resource-poor farmers (Ben Salem & Smith 2008; Kosgey et al. 2008). According to Meena & Singh (2013), livestock diseases epidemics demand constant identification, classification, mitigation and removal of all sources of the epidemic. In order to record, manage and utilize the data on livestock health management, the use of ICT tools like mobile phones web-based applications appears to be playing a greater role in livestock health control, disease and pest control (Kumar et al. 2017). Furthermore, the work published by FAO (2007) reported that the use of mobile phone technology has become a common feature for exchanging and communicating information on disease control, monitoring and pest tracking. In South Africa, South Africa's Disease Reporting System releases on a monthly basis the information on animal health management such as disease control, and how to prevent the disease and pests from spreading (Epidemiology & Health 2016). The reasons for reporting and sharing such information as reported by the author are to:

- Detect, mitigate and prevent the outbreak of critical diseases
- Warn farmers and all stakeholders involved
- Mitigate the negative economic impacts of a disease outbreak
- And finally to control the disease

Another example is the ASKBILL web app (Kahn et al. 2017; Cleeland 2017). Referring to Kahn et al. (2017), ASKBILL is a web-based program that makes use of farm data such as farm capacities, climate data and information on heredities/pedigree to predict and measure pasture growth, livestock performance, livestock health and harsh weather conditions. The application goal is to improve sheep health and productivity so that sheep farmers can adapt to varying climates and seasons. Furthermore, it can assist farmers with mitigating risks from things like flies and worms. The application records data on changing animal requirements and climate change daily to produce accurate, reliable and detailed data. Using the data farmers are be able to adjust sheep stocking rates in a timely way, and also treat animals against impending risks for maximising productivity (Cleeland 2017).

2.4.2.4. Feeding

Increasing demand for animal products, urbanization, population and economic growth for the past years has caused the increase in livestock production, which in turn has affected the environment and natural resources (Udo et al. 2011; Herrero et al. 2010). In most developing countries, livestock farmers depend on natural grazing; and this is because smallholder farmers have been progressing from open grazing-based livestock production. Kumar et al. (2014) reported that there is inadequate information regarding feeding systems, requirements, constraints and production performance of smallholder livestock production because of their geographical settings such as their dispersed distribution. Furthermore, a study by Baloyi et al. (2008), reported that information on feed management is important to farmers who are constantly being affected by seasonal changes and feed shortages. Information on the quality, quantity, and type of feed are essential to smallholder livestock production (Baloyi et al. 2008). In addition, Tadel et al. (2016) suggested that feeding strategies should correlate with livestock production development programs for smallholder farmer's socio-economic benefit and improved decision-making.

In order to mitigate the side effects of the decline in rangeland resources and feed in dairy farming, RFID technology assists with the documentation and monitoring of cattle habits such as feeding. According to The World Bank (2011), the technology has a chip that communicates the cattle's feeding habits such as dietary needs back to the farm's database where it will be analysed. The farmer, manager or supervisor will use the information to determine the correct amount of nutrition for every single animal. The adoption of ICT tools in livestock feed management by smallholder farmers in developing countries is still limited (The World Bank 2011). Using modern technologies, smallholder livestock farmers in developing countries can now have access to information and knowledge on improving feeding management strategies (Kirk et al. 2011). Nwagwu, (2015), reported that commercial farmers depend on ICT tools such as computers to calculate feed /feed formulation. The introduction of mobile phones in livestock production has managed to improve communication between different players in receiving information or necessary advice on livestock feeds and feed markets. Braimok, (2017), reported that acquiring feed was one of the bottlenecks to obtain successful milk production for most women dairy farmers but the use of mobile phones allowed women to procure and obtain feed from anyone for a reasonable amount. The diffusion of ICTs in the management of livestock feed offers necessary opportunities for development in livestock production. According to Ben Salem and Smith, (2008), the development of new technologies must involve the end users because it is evident that participation and contribution of all stakeholders are required for the development of cheap and sustainable feeding management strategies for livestock raised in developing countries under harsh conditions.

2.4.2.5. Finances

The evidence from previous studies show that socio-economic empowerment is one of the reasons why most smallholder farmers in developing countries keep livestock (Herrero et al. 2015; Herrero et al. 2014; Swanepoel 2008). Moreover, Meissner et al. (2013) reported that lack of access to financial information and services reflects the limitations of livestock farming in rural communities. A paper by FAO, (2007) reported that ICTs are providing better and diverse financial services to a large number of rural clients economic efficiency, as they are cost-effective. Furthermore, a study by Nafula, (2016), examined the welfare effects of ICTs on farmers in Rwanda and Kenya. The author reported that the use of mobile ICTs has allowed an efficient and economical way of sharing and exchanging information more extensively.

The use of ICT tools and services in livestock production has enhanced the farmer's access to financial services such as money transfer, micro-finance, credit, money transfer, insurance and banking (Maru 2018; Soffer & Raban 2006). These services are responsible for the development of livestock production because they allow farmers to make and receive payments on mobile phones for supplies and products (Kirk et al. 2011; EconetZW 2013). Masuka et al., (2016), reported that mobile phone financial transactions have assisted farmers with saving time and costs, as many of the farmers reside in remote areas with minimal communication, access to transport, access to basic financial services and poor infrastructure. Furthermore, Kirk et al., (2011) report that these services help improve the rural farmers' agricultural production since the farmers will not have to travel long distances to get access to banks to make transfers and request funds. In Kenya and other surrounding countries, M-PESA a Vodafone's mobile money transfer service is bringing basic financial services to the rural communities (Kirk et al. 2011).

2.4.2.6. Transport and Market

According to Palmer, (2012), ICT development is key to improving livestock production and the value chain. ICTs have become very important marketing tools that allow farmers or other stakeholders to access information on market prices and demand (FAO 2007). With this information on the markets and prices, farmers are capable of making informed decisions to improve revenue and reduce transportation costs to attain market information (The World Bank 2017). A study by Nwagwu (2015), reported that mobile-based services like SMS have enabled farmers to collect information on market prices from the urban communities without a middleman. According to the author, the use of mobile phone to inform customers about the prices and availability of products showed that geographical location does not hinder the use and access to information in developing communities. An example of such a tool is the Esoko Ghana Commodity Index (EGCI). The benefits of this tool towards improving market access and price are shown by the increase in a number of subscribers and users of the tool (The World Bank 2011). According to O'Donnell (2013), ICTs can assist smallholder farmers by enhancing their marketing ways in the following:

- Exploring new markets
- Comparing market prices to acquire the best market prices and manage sales.
- Enhanced traceability and compliance with quality and safety standards.
- Finally, improve the smallholder farmers' profits.

The application of ICT tools as reported in the previous studies has positively influenced the reduction of transport costs as smallholder farmers are using mobile phones to replace travel costs with phone calls (The World Bank 2011; Nwagwu 2015). Although transportation of livestock products is primary, mobile phones can inform farmers where exactly to deliver their products in order to save time and costs (The World Bank 2017). The Zambian National Farmer Organization developed an SMS based service that assists farmers with choosing a market of their choice with reasonable prices for transport costs (The World Bank 2011). This kind of services saves money among smallholder farmers and provides more time for farmers to work on the farm. Another example is the Kenyan Agricultural Commodity Exchange (KACE), which assist farmers with real-time information on logistic services such as transport costs and food quality measurement (Nafula 2016).

2.4.3. Empowering Women and Youth

In agriculture, the livestock sector plays multiple roles in the socio-economic development of rural households and contributes positively to the GDP of most developing countries (Swanepoel 2008). The application of ICT tools such as mobile phones, radios, TVs and Internet services to the agriculture sector presents the opportunity to offer a different way of exchanging and sharing information and knowledge amongst farmers especially women (Braimok 2017). The empirical evidence from previous studies indicates that ICTs have the potential to increase economic growth and reduce poverty in the developing world whilst promoting women and youths participation in agriculture in general and livestock production specifically (Soffer & Raban 2006; Braimok 2017). The evidence from previous studies has identified some of the challenges women farmers have been facing in most parts of the developing world. The challenges include:

- Limited access to banks, financial institutions, and markets
- Social and Cultural beliefs such as
- High illiteracy
- Poverty
- Time and mobility constraints

The empowerment of women in agriculture has a significant factor in mitigating these challenges such as poverty and promote both individual and community development in most developing countries (Pade 2015). According to Treinen & Van der Elstraeten (2018), increasing the number of women's access to new technologies requires that the main technologies are developed to meet the important needs of the female

farmers. In addition, the technology revolution has allowed female farmers to improve sales, increase agricultural production and empower themselves through improved decision-making.

Although ICTs have the potential of empowering women, In Africa, Treinen & Van der Elstraeten (2018), reported that women using the Esoko mobile service to exchange information on farms and agricultural products encountered marital problems, because of suspicions of unfaithfulness by their husbands. A study by Irungu et al. (2015), concluded that the use of ICTs in agriculture improved opportunities, motivation and the position of the youth to engage in profitable agriculture. Furthermore, tools like the mobile phone have improved relationships within communities, overcoming the distance barriers because according to Maru (2018), the large number of smallholder farmers now have access to mobile phones and the youths are quicker to appreciate technology, efficiency, and inventions.

2.5. Database management system for recordkeeping

Database management system (DMS) in simple terms is a computerised recordkeeping system with many services. There are different types of records that a farmer can use to monitor production and other farm operations. A good recordkeeping system has the ability to assist smallholder farmers in making reliable production and management decisions in developing countries (Abegaz et al. 2008; Gizaw, Goshme, et al. 2014). However, a good recordkeeping system does not assure that farm productivity will be a success but according to FAO, (2007), a participatory approach needs to be employed in order to ensure the use of ICT tools like a recordkeeping database is socially accepted and utilised. Evidence suggests that with the use of modern ICTs, livestock farmers are able to record, store and update various characteristics of each animal, such as pedigree, age, reproduction, growth, health and feed conversion (Kumar et al. 2017). Furthermore, the use of a management database within smallholder livestock farmers eliminates the ability of farmers to rely on their memory. According to Scholtz et al. (2013), sustainable livestock production will be slow for particular livestock traits if there is no proper livestock records and measurements recorded.

In the literature on livestock breeding for sustainability to mitigate global warming Scholtz et al. (2013) indicated that a scientifically based central database has many benefits for developing countries that have the ability to participate globally and ensure sustainability in livestock production. Although the concept and definition of sustainability have emerged for the past decades (Mapiye, 2017; Marandure et al. 2018), there has been a slightly noticeable improvement in sustainable livestock production among the smallholder farmers in developing countries (Molotsi, et al., 2017a; Marandure et al., 2018).

After studying the relevant genetic traits for smallholder sheep farming systems in South Africa, Molotsi, et al., (2017a), reported that livestock genetic diversity is significant for sustainable livestock production and livestock reproduction performance. The author further emphasised the need for maintaining the genetic diversity in smallholder sheep farming systems for sustainability. A recordkeeping management database

allows the use of a simple, reliable and economical livestock performance recording system essential for smallholder farmers. However, sustainable livestock production is fundamental to smallholder livestock production in developing countries. Additionally, a good recordkeeping system is necessary for good livestock production and farm management. According to Abegaz et al., (2008), sheep records must show information of individual ewe performance over continuous years on fertility, prolificacy, rearing or mothering ability. The author further identified the two main objectives of recordkeeping as:

1. To allow farmers and other stakeholders to identify the animals and owner (proof of ownership)
2. To use the recordkeeping management tool to:
    - ✓ Manage performance evaluation and performance.
    - ✓ Perform genetic selection.
    - ✓ Accurately measure livestock production and reproduction performance.
    - ✓ Perform traceability.
    - ✓ Perform other farm management activities to ensure sustainable livestock production.

2.6. Database management system as a tool towards sustainable livestock production in smallholder livestock production.

The development of a management database system for recordkeeping for smallholder sheep farmers is important for improvement of recording and analysis processes to achieve sustainable livestock production. The database allows farmers and other stakeholders to identify the best and poorest management practices. Moreover, it provides information for research, policy development and employing genetic improvement programs (Abegaz et al. 2008). On-farm records are essential for sustainability in smallholder livestock farming (Gizaw, Goshme, et al. 2014). However, Marandure et al., (2018) indicated that current sustainability evaluation methods are not capable of incorporating the diverse roles of smallholder livestock production in the livelihoods of smallholder farmers in the developing countries. The role of smallholder livestock towards achieving the various needs of smallholder farmers in developing countries is important. Furthermore, smallholder livestock farmers rely on livestock for manure, milk, meat and income (Swanepoel 2008); however, their socio-economic issues are complicated and many are located in remote areas where there is poor access to services and facilities.

In delivering services to farmers, stakeholders need reliable information from farmers such as the recorded data from the smallholder livestock farmers to give informed advice (Mwanga et al. 2014) and further perform sustainability evaluation using the database as an evaluation tool. However, as with any other computerized programme, the reliability of the information produced is associated to the reliability of the information recorded and stored. A study on dairy technology adoption in Ethiopia (Mekonnen et al. 2010), concluded that improved dairy farm management using high-level technology was directly proportional to the amount of milk

produced. Improving smallholder sustainable livestock production is a central theme in developing countries (Spielman et al. 2011). Moreover, a case study by (Mwanga et al. 2014) of Tanzania, indicated that a database record is essential when a farmer seeks advice from expertise regarding production, management or any other farm operations. Furthermore, the author highlighted that an expertise can search through the database in order to formulate the advice that is significant to the farmer.

2.7. Challenges of using ICTs in smallholder livestock production

Improving production and profits are still some of the crucial challenges affecting smallholder livestock farmers in developing countries (Ben Salem & Smith 2008; Rege et al. 2011). Even though the work from previous studies has concluded that ICTs in livestock production are an important tool in growing productivity (Kirk et al. 2011; The World Bank 2011; The World Bank 2017; Cirera et al. 2016), there is still different views on the level of impact. The adoption of ICTs in developing countries is hindered by a lot of factors such as lack of infrastructure, unreliable power supply, poverty, gender, economic status, social and cultural beliefs (The World Bank 2011). The access to ICTs is not fair yet as identified by previous studies, there is still a gender, age and rural-based digital divide (Treinen & Van der Elstraeten 2018; Irungu et al. 2015; Telecommunication & Report 2010; The World Bank 2017). In addition, the language of development of most ICT tools are using is not yet adaptable to local needs and the contexts is difficult (FAO 2007). Despite the increasing number of mobile phone users (Kirk et al. 2011), the price of accessing ICT services can be very expensive in other developing countries. The charges of internet and ICT services are barriers to most groups of farmers, such as young people, women, old farmers and farmers in most remote areas (FAO 2007).

The report by The World Bank, (2011) and other studies identified some of the following challenges associated with poor ICT utilisation in agriculture:

- Lack of infrastructure to support ICT application in rural communities.
- Unreliable power supply and power cuts
- High illiteracy among the smallholder farmers in most developing countries
- Government Policies and Regulations
- Gender of the farmer
- Age of the farmer

2.8. Summary

The literature showed that for the successful development, implementation and sustainability of ICT agricultural based tools, there is need for integration of all stakeholders. Furthermore, the language of development need to be simple and easy to understand. This chapter focused on the literature review of the research study. The evidence from most of the studies and literature do confirm that ICTs have managed to change the livelihoods of livestock farmers in developed countries and continues to do so in developing countries. Smallholder livestock farmers' productivity correlates with the utilization of ICTs in conjunction with the smallholders input such as traditional farming knowledge and local information. ICTs ensures the exchange/sharing of traditional knowledge and utilization of the information. The majority of farmers who uses ICTs tools have managed to communicate and exchange information, such as weather forecasts, price markets and educating farmers on how to improve their livestock production. Although the use of information and communication technology has managed to improve the livelihoods of some farmers, the evidence from some studies have explained that the actual influence of ICTs on smallholder livestock production in developing countries is still unknown.

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CHAPTER 3. Challenges and benefits of data capturing within smallholder sheep farming systems.

Abstract

The study incorporated the identification and characterization of the challenges affecting the environment and socio-economic livelihoods of smallholder farmers in Ebenheazer and Beaufort West. In the study, 24 respondents participated in the identification and classification of the problems and constraints. Data was collected using a semi-structured questionnaire and SWOT analysis. In both communities the farmers were male dominated with 88% of the farmers were males and about 13% of the farmers did not have any formal education. The responses from the SWOT analysis with farmers showed that poor recordkeeping, unreliable medium for data storage and farm management (bookkeeping, labour and production) were weaknesses towards the development of smallholder sheep production. The farmers said that, "farm management and bookkeeping using a pen and paper was unreliable and time consuming". The farmers identified the use of pen for recording and a book for recordkeeping as a threat to the information stored on paper because books are lost or destroyed. The results highlighted that there was no relationship between the districts of the farmer, the knowledge of keeping records, owning a smartphone with the farmers' willingness to use a web-application tool for recordkeeping. The majority of the farmers (67%), reported drought as the main problem affecting sheep production and productivity with about 66% of the farmers ranking the challenge high. During the interviews, the farmers who were located in areas near towns reported stock theft challenge 'very high'. The conclusion is that sustainable sheep farming in this area is hindered by different challenges and constraints. It is important to develop and implement tools that assist farmers in recording of animal performance and farm management.

Key words: drought, livestock, challenges, recordkeeping, sustainable.

3.1 Introduction

Livestock production is very important in uplifting the livelihoods of most rural livelihoods in developing countries (Swanepoel, 2008). Research recognizes the social, environmental and economic importance of smallholder livestock production. Mahlobo, (2016) reported that farm management of smallholder livestock farmers need to be improved towards socially acceptable methods which are economically profitable and environmentally friendly. However, in spite of the rapid change in the livestock industry (Herrero et al., 2015), it is difficult for smallholder farmers to manage a farm with the methods used by their forefathers (Kwame Tham-Agyekum, Appiah and Nimoh, 2010). A different range of factors limits the improvement of livestock production in developing countries, especially, smallholder sheep production. These challenges and constraints have adverse effects on smallholder livestock farmer's livelihood in developing countries. Previous literature have recognized challenges affecting the sustainable production of smallholder livestock. The challenges include water shortage, feed shortage, poor market access, diseases, less number of stock, drought, predation and theft (Mahanjana and Cronjé, 2000; Swanepoel, 2008; Nardone et al., 2010; Mdladla, Dzomba and Muchadeyi, 2017; Rojas-Downing et al., 2017). Some of the limitations affecting smallholder livestock production include small flock sizes, undefined breeding goals, poor pedigree and performance recording (Kosgey et al., 2006, 2008; Gizaw, Goshme, et al., 2014; Gizaw, Haile, et al., 2014).

Recordkeeping is an important part of good livestock and farm management (Abegaz et al., 2008). The primary purpose of recordkeeping is to use the collected data as a management tool to make informed decisions and perform livestock evaluation (Mwanga, Simba and Yonah, 2014). However, poorly documented information is difficult to analyse and makes it difficult for government extension officers to deliver extension services to farmers. The officers make use of the information such as animal profile, pedigree records and livestock performance to give informed advice and perform livestock evaluation (Abegaz et al., 2008; Mwanga, Simba and Yonah, 2014). DAFF (2013) reported that sustainable livestock production is still low in smallholder livestock production. Therefore, this inhibits the improvement of livestock production within smallholder farmers. Additionally the recording and selection of livestock for better performance in terms of productivity, production, pests and diseases tolerance is still inadequate (Kosgey et al., 2006). Gizaw, Goshme, et al., (2014) reported that pedigree recording did improve the village sheep selection for improvement of smallholder livestock production. However, the author stated that recording of pedigree and animal performance records is effective when the farmer is directly involved. The sheep kept by smallholder farmers in South Africa include indigenous breeds which have adapted to the environment and the weather conditions (Kunene, Bezuidenhout and Nsahlai, 2009). These breeds have characteristics that outperform some exotic breeds in terms of fitness traits, disease resistance and survival traits (Kosgey et al., 2006; Kunene, Bezuidenhout and Nsahlai, 2009; Rege et al., 2011; Molotsi, 2017). Therefore, given the significance of the topic, this chapter focuses on the first objective of this study, which was to identify and characterize the challenges, constraints

and benefits associated with smallholder sheep production by smallholder sheep farmers in the Western Cape Province.

3.2 Materials and Methods

This study followed a mixed method research approach. Wisdom & Creswell (2013) defined mixed methods research as an approach that develops a methodical integration or combining of qualitative and quantitative data within a single research study. The research method accept the notion that qualitative and quantitative methods are compatible and keep the notion of a pragmatist paradigm (Graff, 2014). The paradigm allows researchers to work from views that enable them to explore, discover and examine the problems and matters that are consistent with their beliefs, perspectives and most important to the academic community (Teddlie and Tashakkori, 2009). The sequential exploratory mixed research process in this study is a method designed mainly for two purposes: (a) to explore the challenges and benefits associated with manual recordkeeping and integration of ICTs in recordkeeping of data by smallholder sheep farmers, information needs and access by using both quantitative and qualitative analysis. The data was collected using focus group discussions and interviews with a semi-structured questionnaire. Focus groups discussions aided the developing of a qualitative assessment of strengths, weaknesses, threats, and opportunities of smallholder sheep farmers and other challenges experienced. The field interviews were responsible for the quantitative assessment of the farmer's demographic information and socio-economic conditions.

3.2.1 Description of the study location

The study incorporated two districts in the Western Cape, namely the West Coast (Ebenheazer) municipality in the West Coast and the Central Karoo. Referring to Molotsi (2017), these districts were chosen because they are situated in arid environments and because sheep are commonly produced extensively in these areas. The vegetation of the West Coast district is the Succulent Karoo Biome, while the Central Karoo is classified as the Nama Karoo Biome (Acocks, 1988). The succulent Karoo mainly consists of succulent plants and is a winter rainfall area. The altitude ranges from sea level to 1500m and the mean annual rainfall is between 20 and 350mm. Grass-shrub is the dominant vegetation in the Nama Karoo and the altitude ranges from 1000 to 1400 m. An area receives summer rainfall that ranges from 100 to 520 mm rain per year. In the Central Karoo district, farmers located within a 50km radius from Beaufort West participated in the research. In the West Coast district, farmers in Ebenheazer also participated in the study. The Figure 3.1 shows the map of South Africa, Western Cape Province and the 2 districts of the study.

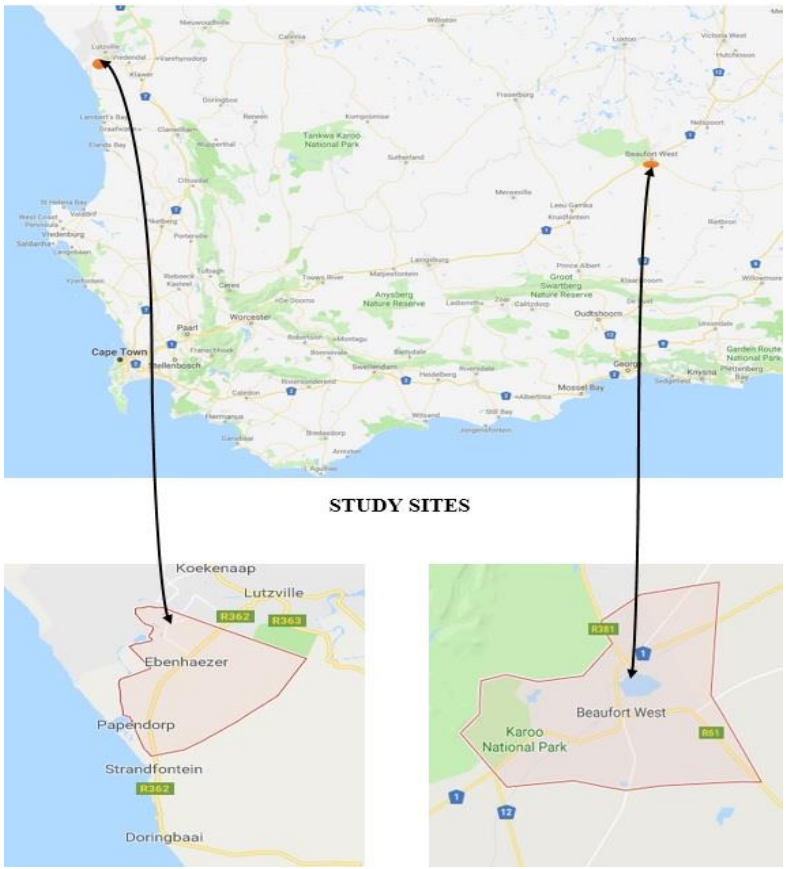

Figure 3.1: Map of the location of the site of study in the Western Cape Province in South Africa. (Ebenheazer and Beaufort West).

3.2.2 Research Population and Sampling Method

The selection of participants/farmers for the study was based on a previous study done in the same area by Molotsi (2017). Participants were selected using a purposeful sampling method. According to Palinkas et al., (1968) a purposeful sampling method is a sampling method that allows the researcher to select participants based on characteristics of a population and the objective of a study. Additionally, the different attributes such as the number of sheep they keep, which had to be between 5 and 100, as well as farmers' involvement in the government projects like CASP, LRAD and PLAS. The government extension officers 'assisted with the information from the two districts respectively. The list obtained from the officers included the farmers involved in governmental projects or receiving support from the government (Molotsi, 2017). Farmers willing to participate in the study were included. The first part of the study involved focus groups discussions using a SWOT (Strength, Weaknesses, Opportunities and Threats) technique to understand the farmer's perceptions and to explore the challenges and benefits associated with sheep farming and integration of ICTs in recordkeeping of data by smallholder sheep farmers. Husbandry practices and flock structure information were collected from the previous study (Molotsi, 2017) and therefore will not be discussed in this study. Fieldwork interviews were conducted with 24 smallholder sheep farmers, 12 in the West Coast and 12 in the Central

Karoo. The different issues included in the survey questionnaire were the challenges and benefits of manual recordkeeping, market access and reliability, government, media use, information needs and accessibility.

3.2.3 Data collection

The data reported and analysed include the farmers' demographics, challenges and benefits associated with sheep farming, integration and use of ICTs in smallholder livestock farming systems. In addition, also the effects of manual recordkeeping in livestock production within smallholder livestock farmers in general and sheep farmers in particular. Data was obtained between the periods of April to August 2018. The FGDs allow the participants to expand their views on different aspects about a matter and moreover, it is possible to obtain different views from a large number of people in a short space of time (Clifford et al., 2016). The government extension officers from both districts supported with the location of the farmers and with assisting in giving an overview of the purpose of the study to the farmers. Trained enumerators assisted with questionnaires. A semi-structured questionnaire is a form of interviewing participants with some degree of predetermined questions but still ensures flexibility in the way participants answer the questions (Clifford et al., 2016). Moreover, a semi-structured questionnaire allows the participants to have an opportunity to explore issues they feel are significant. The questionnaire was in English but in the course of the interviews, Ebenheazer farmers answered the questions in Afrikaans.

3.2.4 Statistical Analysis

To analyse the data, SWOT analysis formed the basis of the qualitative analysis of the study. Thematic analysis was implemented for better analysis of the SWOT analysis data. The analysis is used to highlight, select and examine themes or patterns within data (Alhojailan, 2012). Additionally, the results from the SWOT analysis allowed progress to develop a survey questionnaire for measuring the importance of the need to design and develop a recordkeeping database for smallholder sheep farmers. The information included the environmental/ecological challenges; access to information, stock theft and predation. A SWOT analysis method assists both the researchers and participants in underlining the main strengths, weaknesses, opportunities, and threats of a particular area of study (Yüksel and Dağdeviren, 2007), whilst it further allows the group members to analyse and explore issues cooperatively.

3.3 Results and Discussion

3.3.1 Demographics of Farmers

The information shows that livestock farming (80%) is the main source of income whereas pensions and grants were about 17 % of the participants. This finding concurs with Meissner et al. (2013), Udo et al. (2011), and Thornton (2010) who also stated that livestock is the leading source of income for smallholder farmers in developing countries. However, these findings contrast with Mahanjana & Cronjé (2000) who reported that

only 10 % of the farmers in the Mgwalana district in Eastern Cape showed interests in devoting to small livestock farming. Table 3.1 shows that in both districts of Ebenheazer and Beaufort West, male farmers dominate sheep farming with about 88 % of the participants in the study being males. This finding corresponds with Mahanjana & Cronjé (2000) who also reported that males dominate livestock farming in the Mgwalana district. However, these findings are different from the common observation that majority of the farmers in rural areas are women

Table 3.1: The features and characteristics of smallholder sheep farmers in Ebenheazer and Beaufort West districts.

Factor	**Option**	**Response (%)**		**Overall Response (%)**
		Ebenheazer	**Beaufort West**	
Gender/Sex	Male	83.3	91.7	**87.5**
	Female	16.7	8.3	**12.5**
Level of education	None	8.3	16.7	**12.5**
	Primary	33.4	8.3	**20.8**
	Secondary	50.0	75.0	**62.5**
	Tertiary	8.3	0.0	**4.2**
Household size	Less than 3	25.0	8.3	**16.7**
	3-6	50.0	58.3	**54.2**
	7-10	25.0	33.4	**29.1**
	Greater than 10	0.0	0.00	**0.0**
Ownership of land	Communal	41.7	8.3	**25.0**
	Leased/Hired	0.0	50.0	**25.0**
	Own	25.0	41.7	**33.3**
	Tribal	33.3	0.0	**16.7**
Age of farmer	Less than 35	0.0	25.0	**12.5**
	36-45	33.3	0.0	**16.7**
	46-55	16.7	25.0	**20.3**
	Greater than 55	50.0	50.0	**50.0**
Source of Income	Crops	0.0	0.0	**0.0**
	Livestock	75.0	83.3	**79.2**
	Salary	8.3	0.0	**4.2**

	Other (Pension/Grants)	16.7	16.7	**16.6**

[1]**Responses** (percentage) represents the responses of each district with a sample of 12 respondents

[2]**Overall Responses** (percentage) represents the responses in percentage of the two districts combined with a sample size of 24 participants

Around 67 % of the respondents were married, 25 % were single and 8% widowed. Whilst the main source of labour was family labour. Studies that were done by Marandure (2015), Hosu et al. (2016), and Kumbirai (2016) were coherent with these findings were they stated family labour as the main source of labour for producing livestock for smallholder livestock farmers in developing countries. The mean household size of the participants in both communities was five. The research of Hosu et al. (2016) and Kumbirai (2016) indicated household size as an advantage for smallholder farming systems because it guarantees labour availability for farming activities. The results show that most of the respondents from both Beaufort West and Ebenheazer had a secondary level education with 75% and 50 % respectively. In Ebenheazer, some farmers had tertiary education as compared to the 0 % in Beaufort West. Moreover, this justifies the work of previous studies by Kumbirai (2016), Swanepoel (2008), and Herrero et al. (2014) who also reported on illiteracy among smallholder livestock producers in developing countries. The studiesfi further emphasised that low levels of education were also responsible for the lack of development and improvement within smallholder livestock systems. About half (50 %) of the participants were aged above 55 years, whereas about 29 % were aged below 45 and below. However, this proves the low levels of education and illiteracy in both communities due to the age gap and lack of participation of the youths in sheep production within the two districts. Age plays a role in agricultural development and information accessibility. The ownership of land between two communities differ significantly, with communal and tribal occupying 75 % of the land in Ebenheazer and whereas around 92% of land was either, leased, hired or privately owned in Beaufort West.

3.3.2 Strength, Weaknesses, Opportunities and Threats of smallholder sheep farming in Beaufort West and Ebenheazer communities.

3.3.2.1 Strengths of smallholder sheep farming in Beaufort West and Ebenheazer districts

Referring to Table 3.2, sheep farming has numerous strengths in the two communities. Access to land, government extension officers and stock availability are some of the main strengths of these two study areas, Beaufort West and Ebenheazer. These findings correspond with Udo et al. (2011), who also stated that intensification of livestock production will be determined by mainly on the accessibility and availability of household resources such as land, labour and forages. Moreover, Mdungela et al. (2017) reported why access to land was not difficult to mostly of the farmers because of the dominance of male farmers. However, the author also reported how some participants were having problems due to the lack of land ownership and having more animals on a small piece of land, which results in overgrazing. Most farmers in these areas are involved

in livestock production because of the geographical location of these areas in the semi-arid region. In the semi-arid region of Africa, the production of small ruminants plays an important role in maintaining biodiversity through utilising by products of crops as well as the shrubs in the rangeland (Pollott and Wilson, 2009). The farmers in both communities did identify access to both government and institutional support as a strength. This result concurs with the finding of Ben Salem & Smith (2008) who reported that farmers and government extension workers need to work hand in hand together to promote programmes that ensure the sustainable production of livestock in developing communities. Moreover, Kumbirai (2016) stated that extension officers were an essential source of information for farmers especially farmers who reside in remote areas with poor infrastructure. In addition to the government involvement in sheep production in these areas, the farmers identified institutional support as a strength. This is because of the increase in the number of projects and studies done with the main aim of improving smallholder sheep farming in Beaufort West and Ebenheazer. Moreover, these projects assist in improving cooperation between farmers and other stakeholders.

Table 3.2: The strength of the smallholder sheep farmers in Beaufort West and Ebenheazer districts

	Beaufort West	**Ebenheazer**
Strength	Access to land	Ownership of land
	Stock availability	Access to participate in research with institutions and other stakeholders
	Access to government and institutional support.	Cooperation among farmers
	Access to markets	Access to markets

3.3.2.2 Weaknesses of smallholder sheep farming in Beaufort West and Ebenheazer districts

The study however identified weaknesses within the smallholder sheep farmers in these two districts. Poor farm management, feed shortages, land ownership and water shortages affects the activity of livestock production in Beaufort West and Ebenheazer. These results agree with Lantzos (2013) who acknowledged that farm management plays a major role in today's livestock production development. Moreover, according to Abegaz et al. (2008), farm management is important for farmers, because they can make decisions based on progressive data capturing and recording. This finding is in consistent with the literature which has identified climate change as the major driver of hindering sustainable livestock production in developing countries (Herrero, Asia and America, 2010; Herrero et al., 2014; Molotsi et al., 2017; Rojas-Downing et al., 2017). Additionally, Rust & Rust (2013) and Swanepoel (2008) also reported that effects of climate change are

estimated to be mostly unfavourable for agriculture in many parts of developing countries in Africa. however, Ambrosino et al. (2014) stated that it is important for farmers to understand the variability in farming seasons and rainfall, in order to mitigate the adverse effects of the change in weather patterns.

Table 3.3: The identified weaknesses of the smallholder sheep farmers in Beaufort West and Ebenheazer districts

	Beaufort West	**Ebenheazer**
Weakness	Water and feed availability	Use of book and pen for recording
	Racial issues	Language barrier
	Farm sizes (too small to make a living).	Farm size
	Farm management (bookkeeping, labour and production)	Poor infrastructure for housing livestock

The farmers in Beaufort West identified racial issues, whilst the farmers in Ebenheazer indicated language barrier as a weakness towards the development of sheep production in these communities especially in Ebenheazer. Additionally, the farmers reported that it was difficult for the inclusion of farmers of colour or accepted into farmer's organisation in the central Karoo. This information concurs with Fahrion et al. (2005) and Kirsten et al. (2009) who reported that South African history has been instrumental in most of the problems and issues affecting the agricultural sector especially smallholder livestock farmers in rural communities. Moreover, this is the effect for the cause of low level of education of the respondents, which in turn affects the farmers' access to information, and subsequently the application of ICTs in sheep production, management and marketing of products. Lack of formal and reliable recordkeeping can affect sheep breeding programs were inbreeding can degrade animal performance in terms of production and reproduction. This result agrees with the study of Abegaz et al. (2008) and Lantzos (2013) who reported that recordkeeping and data recording are essentials for developing smallholder livestock production. Moreover, there is evidence from studies that support this finding. Gizaw, Goshme, et al. (2014) reported that difficulty of pedigree and performance recording are key technical limitations to various breeding goals. Other weaknesses of the sheep farmers in these areas include poor infrastructure, farmer's geographical location and land size. There was high dispersion of farmers' location and in turn, farmers find it difficult to have access to information. It is because of this most farmers in remote areas suffer from isolated information exchange (Kirsten et al., 2009).

3.3.2.3 Opportunities of smallholder sheep farming in Beaufort West and Ebenheazer districts

Sheep farming in Ebenheazer and Beaufort West offers tangible opportunities as stated by both the farmers and government extension officers. The development of a recordkeeping database for smallholder sheep farmers in Beaufort West and Ebenheazer will offer to the farmers a platform to improve farm management and sheep production. This finding concurs with Abegaz et al. (2008) who stated that recordkeeping is an important aspect of good livestock and farm management. Moreover, the studies of Gizaw, Goshme, et al. (2014) and Gizaw, Haile, et al. (2014) found out that recordkeeping is more feasible in smallholder villages when farmers are asked to participate in recording. The author further emphasised how the farmers improved their livestock production through improved recording and breeding goals. In addition to improved recordkeeping opportunities, the government funding and loans from stakeholders creates a benefit to the farmers. However, this is in contrast with the finding of The World Bank (2008), it reported that smallholder farmers in general face challenges from financial constraints in agriculture and in most cases funds are unevenly distributed hence preventing smallholders' ability to improve production. Additionally, the author reported that financial problems affecting the farmers are due to the lack of assets to serve as collateral when asking for loans or funds.

Table 3.4: The identified opportunities within the smallholder sheep farmers in Beaufort West and Ebenheazer districts

	Beaufort West	**Ebenheazer**
Opportunities	Establish feedlots	Access to institutions (Stellenbosch University)
	Introduction of the smartphone application	Introduction to new technologies like smartphone application
	Establishing farmers cooperatives	Loans and Funding
	Acquire organic certification for marketing	Constant access to research projects and students

The creation of new modern feedlots allows the farmers to improve sheep health and nutrition to ensure improved and quality sheep production in the communities. The creation of these feedlots is an important opportunity for smallholder sheep farmers to cater sustainably for shortages of feed and other feed related problems. The ability to market and sell livestock products is an indication of how these stakeholders offer different opportunities to the farmers. Opportunities in these communities are responsible for the development of agriculture especially livestock production. Farmers identified teamwork and access to institutions as drivers

towards improving livestock production and farm management. In addition, access to institutions will not only improve sheep production in these communities, but it will improve relations between remote communities and institutions as well as assist farmers with improving sheep production, farm management and livestock products marketing.

3.3.2.4 Threats of smallholder sheep farming in Beaufort West and Ebenheazer districts

The threats of sheep production in Beaufort West and Ebenheazer that can impede the improvement of sheep production are the lack of finance for inputs such as feed and medication, climate change, land size and competition from commercial farmers. The identified threat of land size concurs with The World Bank (2008), the report stated that in developing countries, issues like the land reform programme can promote smallholder livestock production development. In this study, the land is one of the identified core assets of agricultural development. Moreover, Makini et al. (2018) reported that land was an essential resource for rural households in Eastern and Western Kenya. Lack of feed is listed as a threat and this finding agrees with the literature on smallholder livestock farming (Swanepoel, 2008; Mapiye et al., 2009; Udo et al., 2011). Moreover, Pollott & Wilson (2009) identified inadequate feed supplies and poor animal nutrition as constraints which work against development and sustainable small ruminant production and productivity. In the study of the impact of intensifying different types of livestock production in smallholder livestock systems, Udo et al. (2011) stated that smallholder farmers in the study ranked lack of good quality feeds as highest. The effects of these threats such as degradation of the grazing lands and the young generation negative attitude towards agriculture have led to an increase in the migration of youths to urban towns in search for greener pastures. Likewise, Mahanjana & Cronjé (2000) reported that youth migration to urban areas was a causal factor to the high population of elderly farmers in the district of Mgwalana in Eastern Cape Province. The number of families at a single farm has affected the relationship between farmers. There is an unlimited number of conflicts in these shared farms. In addition, competition from commercial farmers is an inevitable threat. Commercial farmers are able to adapt to new technologies faster than most smallholder farmers in developing countries are. This observation concurs with Masuka et al. (2016) who stated that commercial farming was one of the drivers of adopting to of new technologies by the farmers. Likewise, Simpson & Calitz (2014) indicated that about 79% of commercial farmers used the Internet to gather and source information.

Table 3.5: The identified threats within the smallholder sheep farmers in Beaufort West and Ebenheazer districts

	Beaufort West	**Ebenheazer**
Threats	Drought	Climate change (drought)
	Stock theft and predation	Sheep diseases and parasites.
	Land size for sustainable production	Stock theft and predation

	Competition from commercial farmers	Lack of finance for inputs like feed, water and drugs

3.3.3 Challenges, Constraints and Interventions of Smallholder Sheep Farming

Table 3.6 provides the challenges and constraints identified by the participants. To specifically identify the problems confronting the farmers, the challenges and constraints were categorized into environment and social-economic categories. Moreover, the farmers ranked the challenge according to the extent of threat level of the challenges.

Table 3.6: list of the challenges reported by the smallholder sheep farmers classified into ecological and social-economic challenges

Ecological/Environmental	Social-economic
Drought	Education level
Heat waves	Access to information
Cold spells	Gender balance
Windstorms	Livestock size
Soil erosion	Institutional and infrastructural challenges
Plant biodiversity	Source of income
Feed management	Stock theft and predation
Water management	Market challenges (reliability and transaction costs)
Sheep breeding and sheep health	

3.3.3.1 Ecological/Environmental Challenges

Evidence from farmers' responses indicated that smallholder sheep farming in these communities suffered from mainly the effects of drought. Moreover, drought is an effect of climate change. In both communities, they reported drought effects as very high with just above 50% of the respondents in Ebenheazer and almost 85 % in Beaufort West. This challenge concurs with Mdungela et al. (2017) who concluded that drought have a negative impact and remains a threat to agricultural sector development. Similarly, Kosgey et al. (2008) stated that climate change effects are unpredictable threats and the availability of natural vegetation is a problem during drought periods. Although drought was the main environmental/ecological challenge reported by the farmers, they also experienced more heat waves as compared to the other challenges such as soil erosion, plant biodiversity loss, cold spells and windstorms. From the information displayed in. Likewise, Molotsi (2017) reported the effects of change in weather patterns like drought as the second highest constraint affecting

smallholder sheep farmers in the Western Cape Province. The author reported that drought assistances from the government in these communities was still lacking.

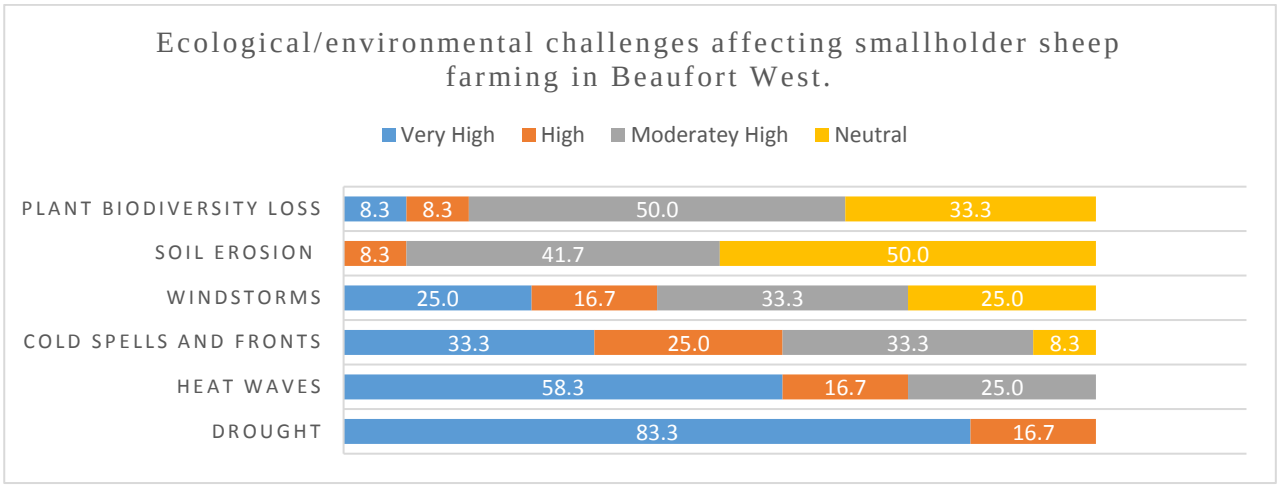

Figure 3.2: The extent (in %) of the ecological/environmental challenges affecting smallholder sheep farming in Beaufort West.

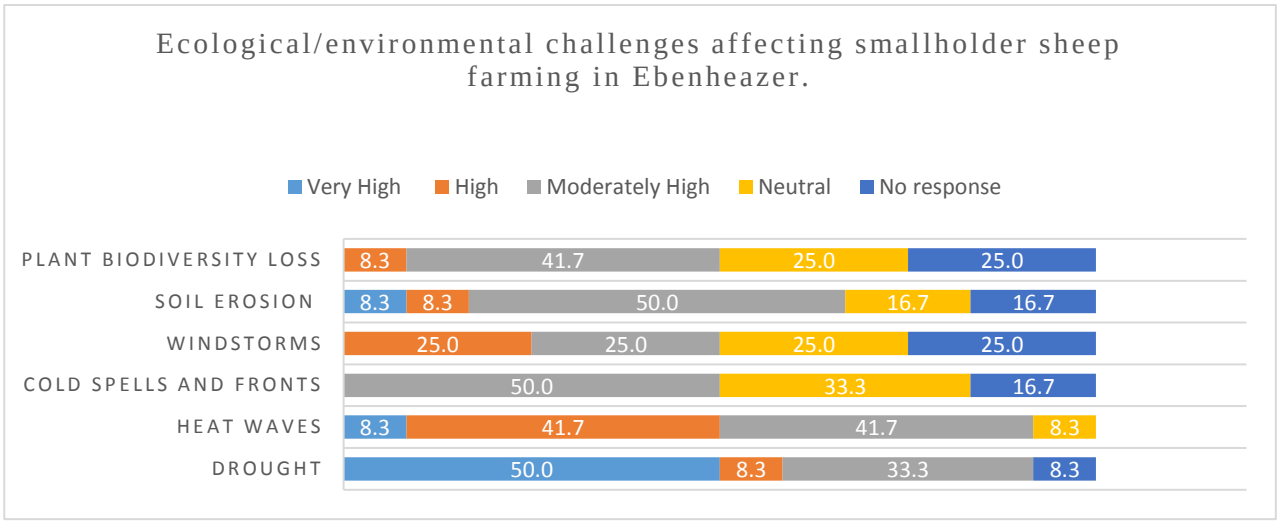

Figure 3.3: The extent (in %) of the ecological/environmental challenges affecting smallholder sheep farming in Ebenheazer.

About 46 % of the farmers ranked the challenge of plant diversity as a moderately high challenge. However, some of the farmers did not have knowledge of the meaning of plant biodiversity. These findings on smallholder sheep farming are also reported by Molotsi (2017), Kunene et al. (2009), Chima and Bowell (2013) and Herrero et al. (2015). Their findings concluded that smallholder livestock farmers faced the challenges of change in climate conditions such as high temperatures, drought, and plant biodiversity loss. In the study by Mapiye (2017), the smallholder cattle farmers in Limpopo Province also reported drought as a severe effect of poor livestock production and development.

Table 3.7 indicates the responses of the participants' vulnerability to the challenges of water and feed shortages respectively. About three quarters of the participants faced challenges of feed and almost half of the farmers have water shortage problem.

Table 3.7: The percentage value of respondents affected by the shortage of water and feed

Variable	**Beaufort West**		**Ebenheazer**	
	Yes (%)	No (%)	Yes (%)	No (%)
Water Challenges and shortages	50.00	50.00	41.67	58.33
Feed Challenges	58.33	41.67	91.67	8.33

In developing countries, smallholder livestock farmers keep small livestock because most farmers rely on natural resources for feed and water (World Bank, 2009; Makhubele, 2016). In both communities, the sheep farmers use natural pasture for livestock feed. Additionally, Makhubele (2016) stated that high dependence on natural resources has made most developing countries inclusive of South Africa to be vulnerable to the impact of climate change. Referring to Figure 3.4 and Figure 3.5, about 75 % of the participants had feed shortages with almost every farmer in Ebenheazer rating this challenge as high. This finding coincides with Mapiye et al. (2009) who concluded that shortage of feed was one of the highest ranked constraints towards sustainable livestock production in the Eastern Cape Province of South Africa.

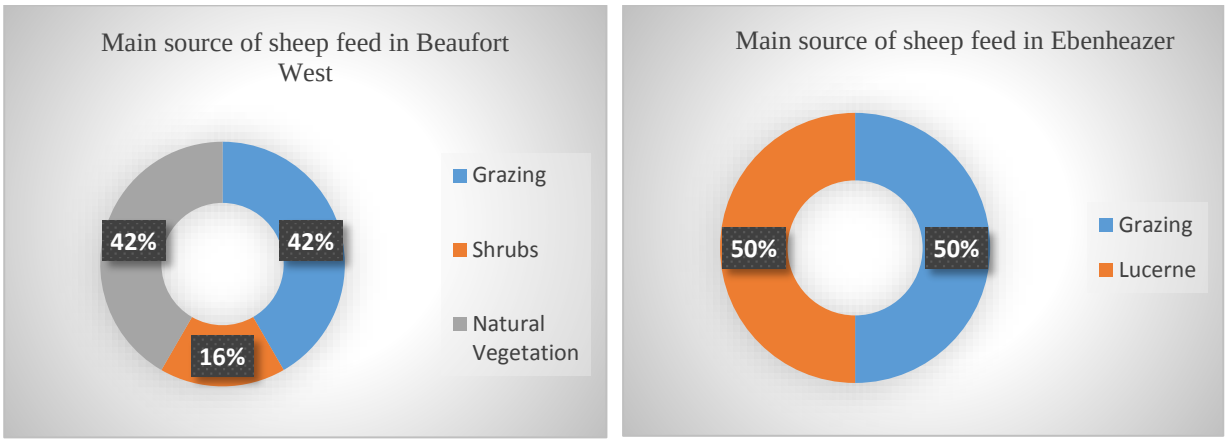

Figure 3.4: Statistical representation of the main source of feed in Beaufort West and Ebenheazer respectively

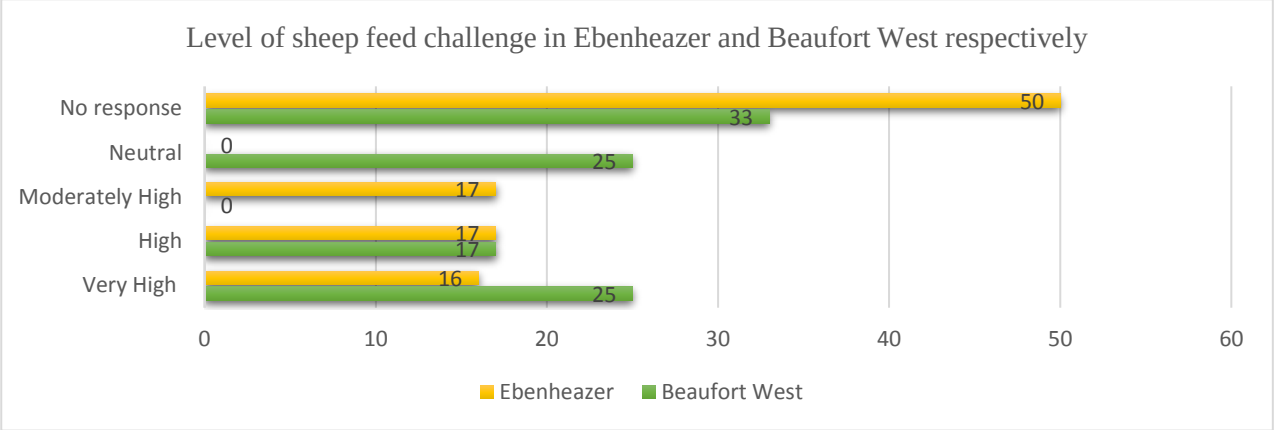

Figure 3.5: Statistical representation of the main source of feed and level of extent of the challenge of sheep feed in Ebenheazer community.

Few farmers in this study managed to mitigate the constraint of feed shortages through introducing methods like livestock rotation in camps and produce extra feed through planting wheat and lucerne. In order to reduce ewe abortions, the farmers separate the lactating ewes in paddocks where they feed them extra feed. In both communities, the farmers stated that drought relief from the government aided them in overcoming feed shortages. In Beaufort West, a handful of farmers were aware of reducing livestock in order to curb the shortage of feed for the livestock. The process of destocking was reported by Ben Salem & Smith (2008) as an intervention livestock farmers used to reduce the impact of drought and feed shortage.

Figure 3.6 and Figure 3.7 display the farmers' perceptions on water shortages as well as the level of extent of the constraint. In this study, about 50% of the respondents indicated they were facing problems of water shortages on their farms. The majority of the farmers observed the constraint level as neutral, followed by about 21% who perceived the challenge to be relatively very high. The shortage of water was reported by Mapiye (2017) as not only affecting livestock production. The author explained how some of the farmers had to fetch water for livestock from distant water sources as far as 20 km. Elsewhere, Hosu et al. (2016) recommended that farmers and other stakeholders need an integrated water harvesting method to eliminate the unavailability and contamination of water in Eastern Cape.

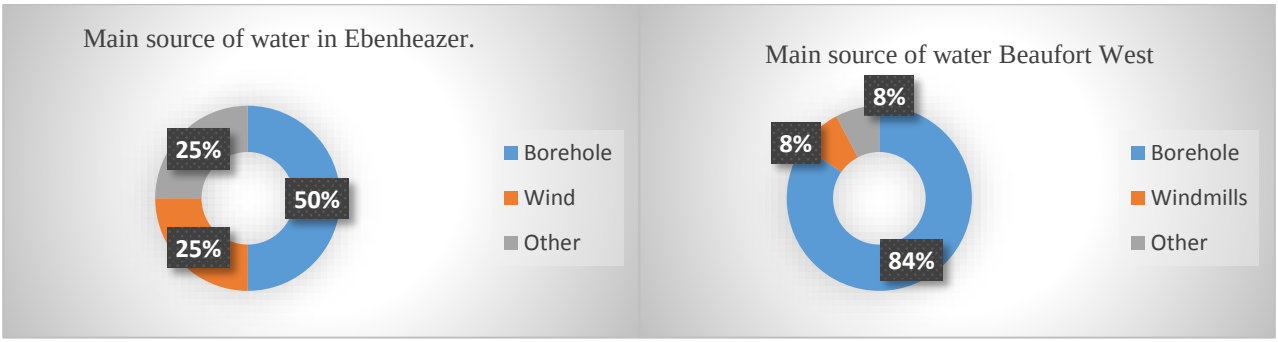

Figure 3.6: The display (in %) for the main source of water in Ebenheazer and Beaufort West

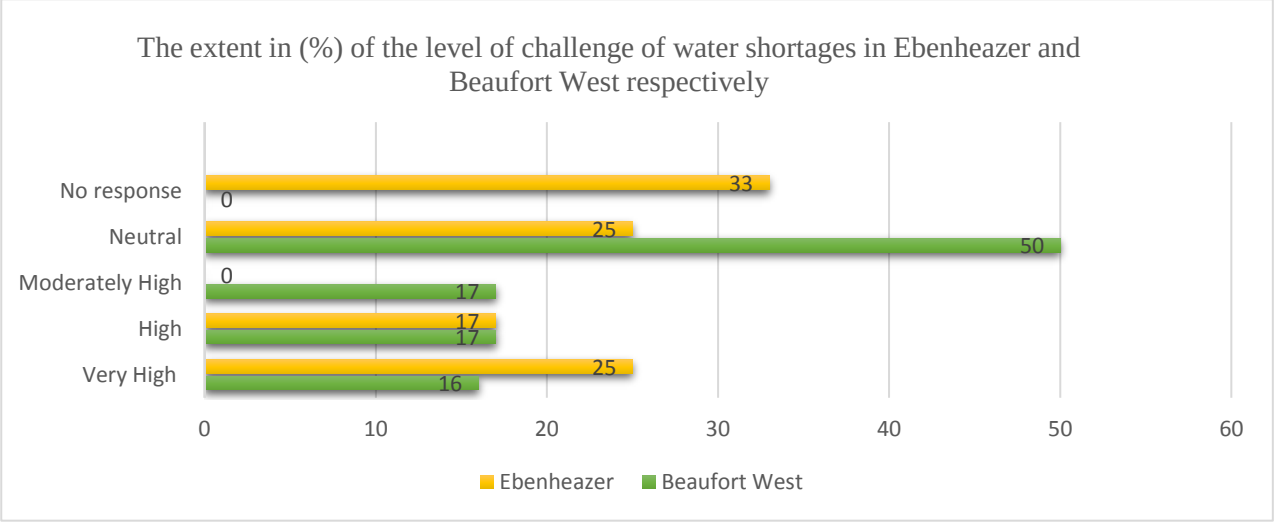

Figure 3.7: The ranking of the extent of the level of water challenge by the smallholder sheep farmers in Ebenheazer and Beaufort West districts.

In this study, farmers ranked borehole water as the main source of water supply for sheep production. About 67% of the participants used borehole water whereas the remainder relied on other water sources such as wind pumps and rain. This finding agrees with The World Bank Group (2017) which stated that piped water, protected dug wells and boreholes are examples of improved drinking water source. Likewise, Makhubele (2016) in the study of the rural smallholder farmers perceptions on the challenges and approaches of climate change in Mopani district in Limpopo Province, the author recommended that government should drill boreholes in rural communities to assist farmers in sustaining farms as there are issues of water shortages. In both communities, the majority of the farmers did not use any method to prevent the challenge of water shortage in case of drought, or high temperatures but others made use of solar and engine pumps in case water problems arise.

The information in Table 3.8 indicates that about 98% of the farmers have reported sheep health as a major constraint to improving smallholder sheep production and management. Fifty percent of the participants ranked the challenge as moderately high followed by 25% who ranked the challenge to be neutral, whilst 17% considered the challenge high and the remaining 6% categorized the challenge as very high. The farmers stated that parasites and pulp kidney were the major causes of the deterioration of animal health. This finding concurs with Molotsi (2017). The author reported that internal parasites, pulpy kidney and blue tongue were the most treated diseases by the smallholder sheep farmers in the Western Cape Province. Also, Kosgey et al. (2008) reported on how poor animal health is a hindrance to sheep and goats production. In the study, the author emphasised how animal healthcare is vital for breeding programmes. Also, Mdladla et al. (2017) stated how animal health was highlighted as a major constraint across provinces. However, according to Rust & Rust (2013), climate change is the main driver mostly through its adverse effects on feed, water resources, land, sustainability, and animal health. Half of the respondents considered livestock breeding was a challenge

towards sustainable livestock production. About 38% of the participants ranked the extent of the challenge high and 25% ranked it 'moderately high'.

Table 3.8: The response of the farmers if either they encounter sheep breeding or health challenges in Beaufort West and Ebenheazer districts respectively

	Beaufort West		Ebenheazer	
	Yes	**No**	**Yes**	**No**
Sheep breeding	50	50	50	50
Sheep health	83.3	16.7	100	0

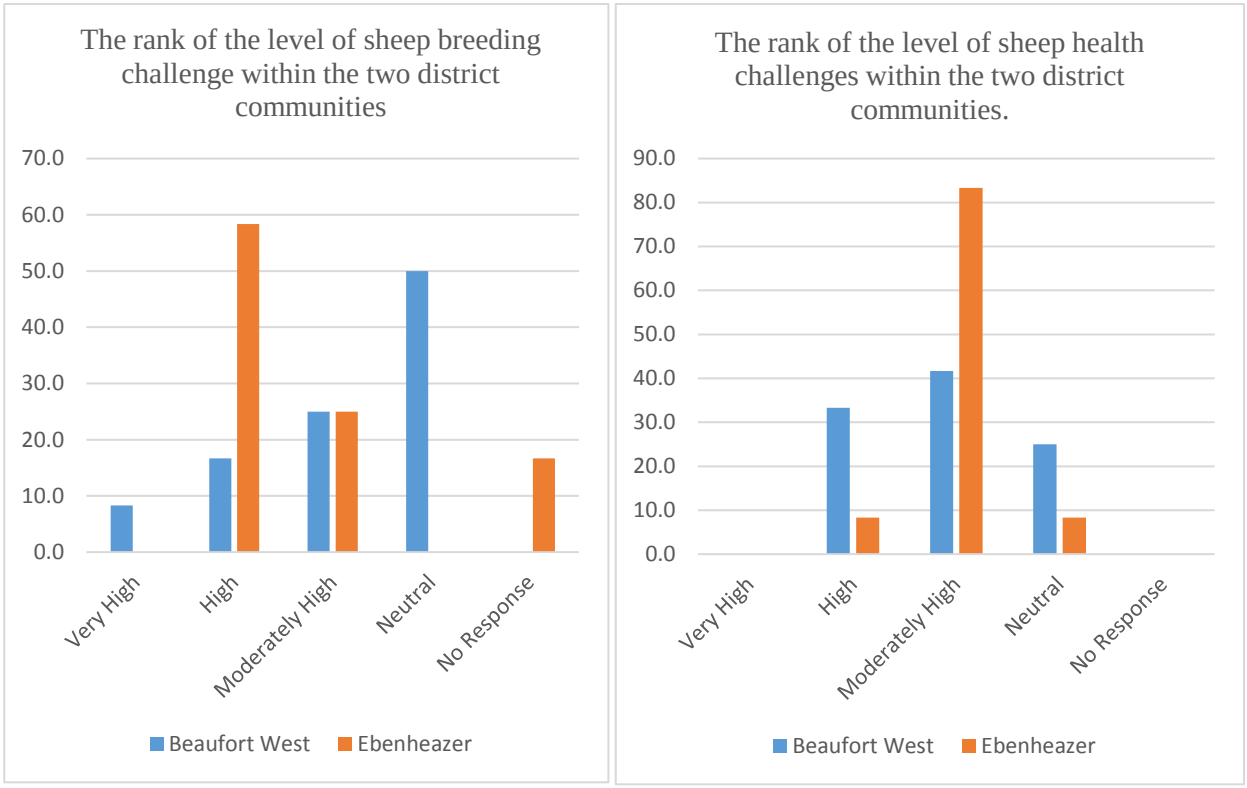

Figure 3.8: The rank of the sheep health and breeding challenges according to the smallholder sheep farmers in Beaufort West and Ebenheazer districts respectively

Largely, the farmers reported drought as the main effect of poor breeding and high mortality rates. Animal loss due to adverse climate conditions has a negative impact on the socio-economic well-being of the farmers. In the study of how the adaptive capacity of smallholder mixed-farming systems to the impact of climate change, Mthembu & Zwane (2017) indicated that drought affected the socio-economic status of the community. The farmers had to destock livestock to adapt to drought effects. In addition, the farmers faced challenges of the lack of quality breeding ewes and rams, predators, miscarriages and unrestricted sheep movement in camps. Although sheep breeding was facing a number of challenges and constraints, the farmers had practiced some intervention methods to mitigate these effects. The farmers use dogs and hunting methods to eliminate predators whilst sometimes they patrol in camps on a regular basis. Some farmers are trained to select animals

with better production skills and this intervention concurs with Kosgey et al. (2008), and Gizaw, Haile, et al. (2014) who recommended that to have success in livestock breeding, the production system must be viewed as a whole, and allow farmers to participate in every stage of the programme. Finally, in Beaufort west the farmers make use of the government programs to test for ram fertility by collecting the sperm to test for quality of the rams.

3.3.4 Social-Economic Challenges and Interventions

The farmers in these communities faced challenges and constraints that affected and derailed the farmers from sustainably producing, marketing and selling livestock. In addition, most of the interviewed respondents (79%) indicated their main source of household income as livestock production, whereas around 17% received government pensions and grants, and the remaining 4% depended on salary. This finding is in contrast with Mahanjana & Cronjé (2000) who reported that above 50% of the farmers in Mgwalana district identified government pensions and grants as the major source of income. This is because in most developing countries smallholder farmers, unlike commercial farmers, they tend to keep livestock for family needs rather than for business needs (Kosgey et al., 2008). Whereas, Bedhiaf (2018), reported that in Tunisia, smallholder sheep farmers ranked sheep production as the main economic activity. However, although the farmers in Ebenheazer and Beaufort West had a number of socio-economic challenges and constraints there were also interventions farmers used to reduce the extent of this challenge. The interventions included reducing the amount of livestock, creating feedlots and selling livestock via the informal sector. Moreover, Kosgey et al. (2008) and Pienaar & Traub (2015) identified illiteracy, inadequate funds, poor infrastructure and poor access to adequate and reliable information as some of the main hindrances to tackling the socio-economic barriers.

Table 3.9: The table of the farmer's response on the level of extent of some drivers of socio-economic related challenges of farmers

	Beaufort West response (%)		**Ebenheazer response (%)**	
	Yes	**No**	**Yes**	**No**
Stock predation	100.0	0.0	100.0	0.0
Stock theft	41.7	58.3	91.7	8.3
Market transaction costs	75.0	25.0	41.7	58.3
Market reliability challenge	16.7	83.3	25.0	75.0

The information presented in Table 3.9 represents the farmers' response to the questions concerning some drivers of the socio-economic challenges. Livestock production is a major employer of smallholder livestock farmers especially in the rural communities of developing countries. Table 3.1 and Table 3.9 reveals the information on drivers of socio-economic characteristics of respondents. The information shows that 50% farmers are in the age group of 56 years and above. Although the finding concurs with the research from other

studies, Masuka et al. (2016) reported that adoption of new technology for farming purposes was influenced by age, commercial farming activities and total income. In this study, the difference between the age groups of farmers signifies that more farmers were older age group farmers, which is not economically active compared to other age groups. However, other scholars have identified age to play a significant role in agricultural information accessibility and dissemination (The World Bank, 2011; Mabika, 2015; Tijjani, Anaeto and Emerhirhi, 2017). According to the scholars, the younger age groups are more open to implementation and use of new technologies than older people are. Irungu et al. (2015) posited regarding age that use of ICTs in agriculture in Kenya has improved opportunities, encouraged and increased the ability of the youth to engage in agriculture. Around 88 % of the respondents were males and 12% are females. Sexuality/Gender of the farmer play a veritable part in access to agriculture resources such as land, labour, markets and information on developments and innovations (Herrero et al., 2014; Tijjani, Anaeto and Emerhirhi, 2017). About 63% of the respondents have secondary education, primary education (21%), tertiary education (4%) and 13% had no formal education. A growing body of literature shows that education emancipate and empowers a farmer. In the study of Tijjani et al. (2017), Mabika (2015) and Msavange (2015), the authors stated that farmers with formal education are more flexible and susceptible to new ideas than those who are uneducated and illiterate. However, this finding is contrast with Masuka et al. (2016), who reported that years of education did not influence the use adoption and use of mobile technologies among smallholder farmers in Marondera.

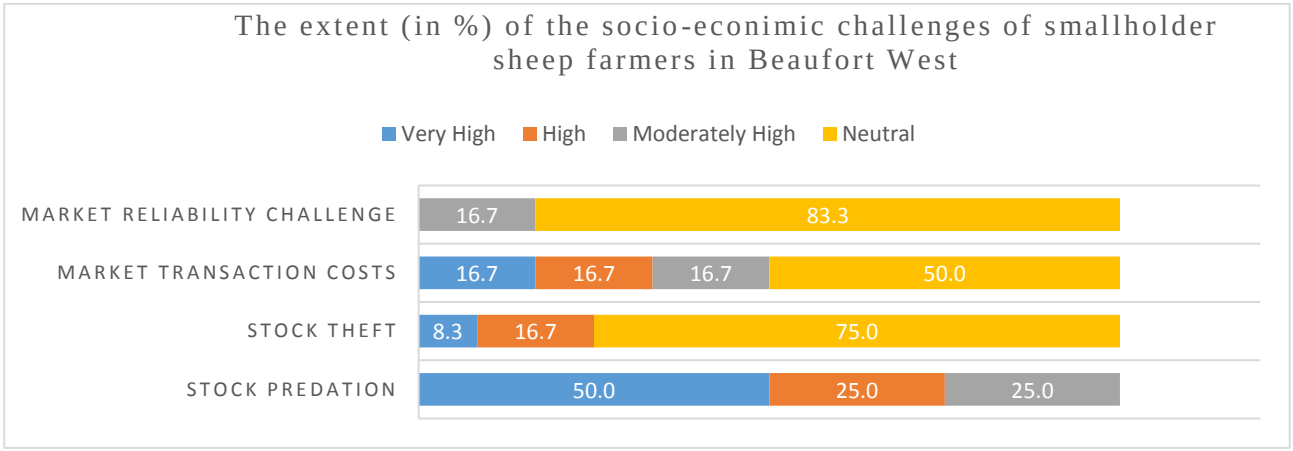

Figure 3.9: The display of the response of the farmers on the extent (in %) of the socio-economic challenges of smallholder sheep farmers in Beaufort West

Everyone who participated in the study was facing the challenge of livestock predation, with the majority of the farmers (100%) responding to facing the challenge. Figure 3.9 and Figure 3.10 show the display of the level of extent of each challenge on the socio-economic livelihood of the smallholder sheep farmers in both districts. About 55% of the farmers ranked predation challenge as very high, 29% ranked it moderately high and about 17% ranked the extent of the challenge high. Outcomes from the survey confirmed that 67% of the

respondents faced the sheep theft challenge (Table 3.9). Thirty-seven percent of the farmers ranked the challenge extent level to be neutral, 29% ranked the extent 'very high', 21% ranked the challenge 'high', 8% was moderately high and 4% were no response. Mapiye (2017) stated that smallholder cattle farmers in the Limpopo province placed stock theft and predation as a challenge affecting smallholder cattle production.

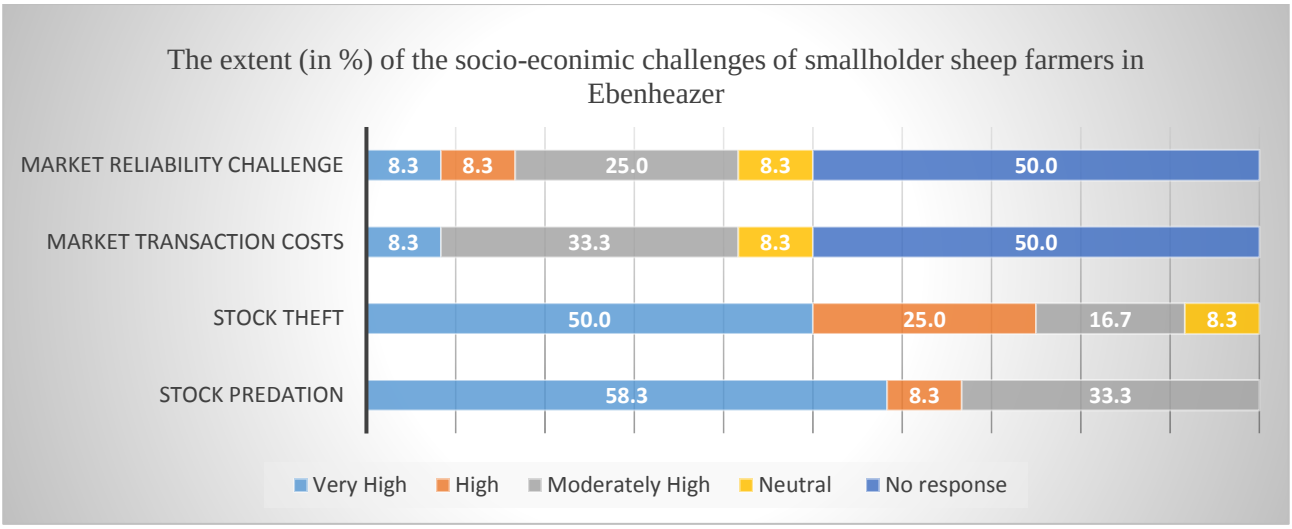

Figure 3.10: The display of the response of the farmers on the extent (in %) of the socio-economic challenges of smallholder sheep farmers in Ebenheazer district

The farmers in Ebenheazer and Beaufort West mentioned that stock theft challenge was more in areas located near to town. However, this finding is in contrast with Mapiye (2017) who reported that stock theft in these communities was not related with the information of the farmers such as district, gender, age and education of the farmer. Farmers in Beaufort West and Ebenheazer reported high risks of predators such as jackals, red cats, baboons and dogs. Among the farmers, there was high correlation between the location of the farmer and vulnerability to predators like baboons. The baboons affected those who resided close to mountains. This finding concurs with Mapiye (2017), and Chaminuka et al. (2012) who posited that farmers who were highly vulnerable to predation of livestock were residing in areas near or adjacent to the Kruger National Park. In order to mitigate the challenges of stock theft and predation, the farmers set traps, monitor the camps regularly, lock gates, use radio to communicate with other farmers and report to the police station

Referring to Table 3.9, more than 41% of the farmers are confronted with the challenge of market reliability. Whilst more than 70% indicated, they faced market transactional costs. The majority (46%) of the farmers ranked the level of market challenge as 'high' while 25% did not give a response of the level of extent of the challenge. This finding is in contrast with Oni et al. (2010) and Adesehinwa & Okunlola (2000) who reported that smallholder livestock farmers in indicated market reliability as a stumbling block towards the mitigation of socio-economic related challenges. Moreover, Mdungela et al. (2017) reported that absence of adequate, and reliable market information is a challenge in developing countries smallholder farming community. In

addition, the author emphasised that market access is vital for the smallholder farmers susceptible to drought. In this study, farmers did not have a major problem accessing markets. This is because of the partnerships between the farmers and various stakeholders in these communities such as BKB, and CPAC. This result is in accord with Nafula (2016) who identified that farmers who were in partnership with livestock stakeholders managed to sell livestock products directly to the market. However, the author also stated that accessing market information is a challenge mainly for the elderly farmers and recommended that ICT mediums such as a radio was needed in order to take note of price information. Also, the lack of reliable and quality market information in the smallholder sector is caused by minimised use of ICT sources of information such as radios and the internet (Temba et al., 2016).

In addition to the challenge of market reliability, farmers heavily emphasised on the challenges related to market transactional costs. However, these challenges have affected the smallholder farmers' involvement in different markets. About 13% of the farmers ranked the challenge, as 'very high' while 25% highlighted that it was 'moderately high' and 'neutral' respectively. Also 29% did not give a ranking to the challenge. This was because these farmers had no idea what amount is considered a transactional cost since they were in content with the input from the stakeholders. In the study, towards the sustainability of smallholder farmers in Limpopo Mapiye (2017) reported that participants in the study stated that money from their products and livestock sell is heavily affected by the cost of transport to markets. However, the author highlighted there was no association between the farmers' characteristics such as location and gender to the challenge of market transactional costs. The farmers have practiced interventions to mitigate the challenges of market reliability and transactional costs. In Ebenheazer, the farmers stated that bypassing the intermediaries will have positive returns and others highlighted informal market as the alternative. This finding concurs with Nyamushamba et al. (2017), Mthembu & Zwane (2017) and Kosgey et al. (2008), the authors identified the role smallholder livestock farmers play in developing countries through the selling of livestock products in the informal markets. Moreover, there is competition from commercial farmers. Commercial farmers outclass smallholder farmers on markets because of the quality and quantity of their products and farming practices as compared to smallholder livestock farmers in developing countries.

3.4 Conclusion

The findings reported above exposed some of the challenges, constraints and interventions that encounter smallholder sheep farming in Beaufort West and Ebenheazer. These challenges were categorized according to their impact on ecology/environment and socio-economic activities of the farmers. The farmers identified drought as the major ecological challenge. The effects of drought included the decrease in rangeland conditions, or grazing conditions, lack of feed, water shortage and loss of plant biodiversity. From this, it can be concluded that other stakeholders must involve the farmers in every part of decision-making and programme development to curb the effects of drought, which is a characteristic of climate change. The use of book and

pen for recordkeeping was a problem towards the improvement of sheep production in the communities. In the study the author reported that farmers who had better and reliable records managed to improve livestock production and productivity. According to the challenges affecting the socio-economic livelihood of the farmers, the farmers identified sheep health, breeding, and markets were limitations to smallholder sheep farmers' production development. In addition, livestock predation and theft are both inevitable in these communities. Therefore, it is of great value to the government and other stakeholders to include the farmers in taking a leading role in mitigating and preventing these challenges. Moreover, in the communities some farmers are already using interventions to tackle some of these challenges such as water shortages, diseases and feed shortages. The farmers introduced feedlots and boreholes to mitigate the feed and water shortage challenges. It is therefore important to develop and create initiatives to improve smallholder sheep farmers, farm and livestock management programmes encouraging the use of technology. These initiatives can assist and enable the farmers to create, record, store and share messages among them and stakeholders.

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CHAPTER 4. The identification and characterization of important factors for the development of a web-application for recordkeeping.

Abstract

The study focused on the identification and characterization of the information farmers identified as important for the development of the web-application. The identification of the main sources of information was according to the response of the farmers. Moreover, the results of this chapter identified the main sources of information, the design and development of the recordkeeping web-application for the smallholder sheep farmers. The farmers ranked government extension officers (54%) as the main source of acquiring information although some preferred information from other farmers. The mobile phone was the main mode of communication amongst the farmers with about 67% owning a smartphone. In addition, the farmers reported that mobile communication saves time and money. The challenges of the current recordkeeping systems of farmers included damage of exercise books, time and loss of records. Although the smallholder farmers indicated poor internet access and power cuts as challenges to the utilisation of the application, the farmers reported that the web-application could assist them in improving farm and livestock management issues such as recordkeeping, data capturing and issues of traceability.

Key words: recordkeeping, database, communication, data capturing

4.1. Introduction

Recordkeeping is vital for the improvement of livestock production for smallholder sheep farmers in the Western Cape Province, South Africa. The new recordkeeping web-application uses the internet and it allows the farmers to document livestock (sheep) records online. As highlighted in the previous chapter, small flock sizes, undefined breeding goals, poor pedigree and performance recording are hindrances to sustainable livestock production (Kosgey et al., 2006, 2008; Gizaw, Goshme, et al., 2014; Gizaw, Haile, et al., 2014). In the absence of reliable and adequate animal and farm records, it is difficult for government extension officers and other stakeholders to provide extension services to farmers. The government extension officers make use of information such as animal profile, pedigree records and livestock performance to give informed advice and perform livestock evaluation (Abegaz et al., 2008; Mwanga, Simba and Yonah, 2014). Some of the challenges confronting the current recordkeeping methods/systems used by smallholder livestock farmers include loss of record books, destruction of books and memory loss through forgetfulness (Mwanga, Simba and Yonah, 2014). Furthermore, Mwanga et al. (2014) reported that one main challenge established for smallholder dairy farmers was the excess amount of paper used for the recordings and manual recordkeeping. Jeyabalan (2010) emphasised that manual recordkeeping is slow, monotonous to discover essential data and make informed decisions.

Nevertheless, studies have shown that adequate and accurate farm records are essential to farmers for purposes of effective planning and farm management (Devonish, Pemberton and Ragbir, 2000; Kwame Tham-Agyekum, Appiah and Nimoh, 2010; Lantzos, 2013; Gizaw, Goshme, et al., 2014). Gizaw, et al., (2014), explained that livestock pedigree and performance recording was only reliable if the farmers were involved in the recording and storing of livestock or farm data. There are traits that a farmer can select for or against, but all these need accurate recordkeeping. Although the recording of livestock performance is a prerequisite to good farm management and performing a genetic improvement programme (Gizaw, Goshme, et al., 2014), in South Africa, there is a lack of formal recordkeeping systems in place for smallholder sheep farmers (Molotsi, 2017). To mitigate this challenge one recommended method is to use information and communication technologies (ICTs) to develop an online database (web-application) for recordkeeping to better livestock production and livestock management for smallholder sheep farmers. However, the use of online recordkeeping system by smallholder farmers is very rare and not given importance (Jeyabalan, 2010; The World Bank, 2011). It is vital and useful to acquire animal performance and pedigree records for the improvement of a sustainable livestock breeding plan to improve livestock production (Gizaw, Goshme, et al., 2014; Molotsi, 2017). Therefore, this chapter deals with the identification of the farmers challenges on acquiring and communicating information, the development of a recordkeeping database for sheep farmers in Beaufort West and Ebenheazer. Moreover, the comparison and differentiation of the information collected from the smallholder sheep farmers and the findings of other studies on the development, adoption, and use of ICT tools within smallholder livestock farmers.

4.2. Materials and Methods

4.2.1. Study site and farmer selection

The study site location, farmer selection and period of data collection is described in Chapter 3 section 3.1.

4.2.2. Data Collection

The data collected and reported in this chapter include the sources of information farmers use to communicate and share information, designing of the recordkeeping database, and the farmers' perceptions on use and integration of ICTs in smallholder sheep farming systems. A survey questionnaire was used to collect data. The data collected included the response from farmers and the information/variables farmers wanted to be included in the development of a recordkeeping database

4.2.3. Data analysis

Data was analysed using RStudio and Gephi. The analysis in RStudio indicated the appropriate statistical measures such as the summary statistics like frequencies, percentages, and averages. Logistic regression in R assisted with checking the association between the perceptions of the farmers towards the development of a recordkeeping database and features such as education age and gender. Regression analysis is a statistical process that allows one to study the association between two or more variables of interest in a study (Wan, 1996). Logistic regression was used to analyse the association between two or more variables such as the willingness of the farmers to use the database and factors like age. Gephi software analysis tool was responsible for the analysis of the social network information such as the main source of communication among the farmers and other stakeholders (Martin, 2015). Gephi is a free software available online. It is a software package designed in Java for network analysis and visualization of the behaviour of networks.

4.3. Results and Discussion

4.3.1. Sources of Information

Table 4.1 shows the response of the farmers; about 84% of the respondents did not face the challenge of accessing information in Beaufort West compared to around 42% of the farmers in Ebenheazer. This finding is in contrast with researchers who have claimed that smallholder livestock farmers in developing countries have largely been involved with poor access to adequate and reliable information (Blattman, Jensen and Roman, 2003; The World Bank, 2011; Mapiye, 2017). Additionally, Mwanga et al. (2014) described that farmers in Arumeru district identified the lack of access to adequate and reliable information as the main problem of improving and sustaining smallholder livestock production. In both districts of Ebenheazer and

Beaufort West, 50% of the smallholder sheep farmers obtained their information mainly from the agriculture extension officers whilst others indicated agriculture trainings and other farmers as source of information.

Table 4.1: The response of the smallholder sheep farmers in Ebenheazer and Beaufort West districts concerning the mode and main sources of accessing, using and disseminating information.

Variable	Option	Response (%)	
		Ebenheazer	Beaufort West
Accessing information	Yes	**58.3**	**16.7**
	No	**41.7**	**83.3**
Mode of communication	Mobile phone	**50.0**	**66.7**
	Word of mouth/face to face	**25.0**	**25.0**
	Other	**25.0**	**8.3**
Main source of information	Government Extension Officers	**50.0**	**50.0**
	Other farmers	**16.7**	**41.7**
	Media/Agricultural training institutions/Other	**33.3**	**8.3**
Own a smartphone/computer	Yes	**41.7**	**91.7**
	No	**58.3**	**8.3**

Figure 4.1 shows the display of where the smallholder sheep farmers acquired information. Each circle indicates the source of information used by different farmers. The circumference of each circle indicate the number of farmers and the farmer is at the centre. The figure shows that government officers (extension officers) are the main source used to acquire information by farmers followed by other farmers, media personnel including agriculture institutions, and internet and lastly mohair unions.

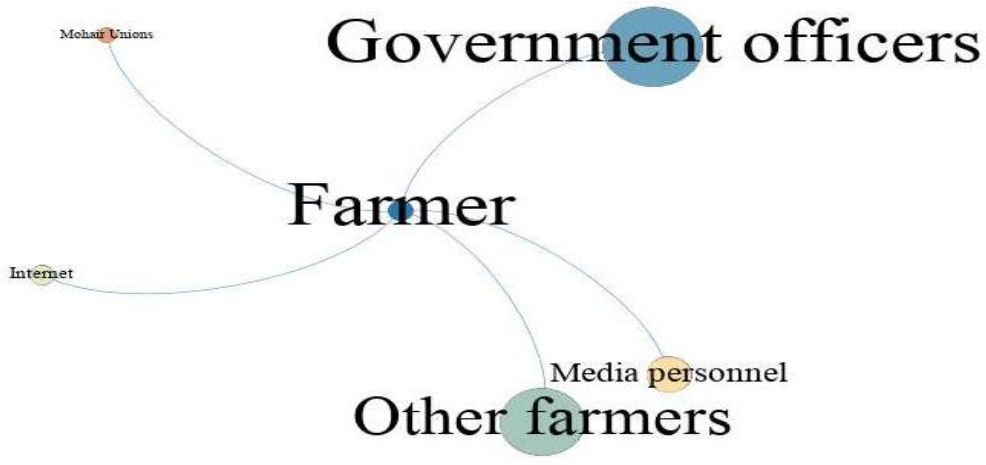

Figure 4.1: Gephi network analysis output. The main source of acquiring information for farmers in Ebenheazer and Beaufort West

This finding concurs with Mwanga et al. (2014) and Mapiye (2017) who reported that smallholder farmers received most of their information from agriculture extension officers. Moreover, this justifies the work of previous studies by Kumbirai (2016), Swanepoel (2008) and Herrero et al. (2015) that also reported on how extension officers were assisting in closing the information gap within smallholder livestock farmers in developing countries. However, the finding is also in contrast with, the (Mahanjana and Cronjé, 2000; Spielman et al., 2011; Goswami, Saha and Dasgupta, 2017), who reported that geographical location of the smallholder livestock farmers in developing countries played a big part in having access to information from government extension officers. In addition, Mwanga et al. (2014) indicated that while most farmers relied on extension officer services, the officers were not always available to assist efficiently all livestock farmers. The author reported that location of the farmers required the extension officers to travel long distances, which in turn affected the extension services.

4.3.1.1. Mode of communication

The results in Table 4.1 shows that farmers in both communities Ebenheazer (50%) and Beaufort West (about 67%) used mobile phone for communication, whilst in Beaufort West around 42% preferred face-to-face conversations or word of mouth and about 33% in Ebenheazer used other modes of communicating such as media, agricultural institutions, and the internet. This outcome concurs with Mabika (2015), who reported that respondents preferred mobile phones as a medium of communication. Besides, Blattman et al. (2003) and Kabbiri et al. (2018) stated that ICTs and other media were mostly used for news, entertainment and communicating with families but not for advertising their products through exploration for and exchange of information on livestock production and market prices. Moreover, Sife (2010) concluded that mobile phones provided rural households with easy and fast mode of communication. The study indicated that mobile phones assisted the participants in getting support during emergencies. However, this finding is in contrast with Mapiye (2017) who reported that majority of the smallholder livestock farmers (56%) in Limpopo preferred communicating via word of mouth or face-to-face conversations. Additionally, 66.7% of the respondents owned a smartphone and 33.3% did not own one. This finding concurs with Blattman et al. (2003) who stated that rural households were willing to spend money on communication and media such mobile phones regardless of the price.

Figure 4.2 shows the variation of smartphone ownership among the farmers. The data shows that in Ebenheazer young farmers owned more smartphones than the old age farmers do. Whereas in Beaufort West the ownership of smartphones is distributed normally amongst the age groups. The younger generation favoured using smartphones more than the former mobile phones. This study concurs with Irungu et al. (2015) and Telecommunication & Report (2010) who indicated that usage of ICTs in agriculture has attracted the youth in taking part in profitable agriculture targeting niche markets. In addition, the young generation appreciate technology, efficiency and innovations.

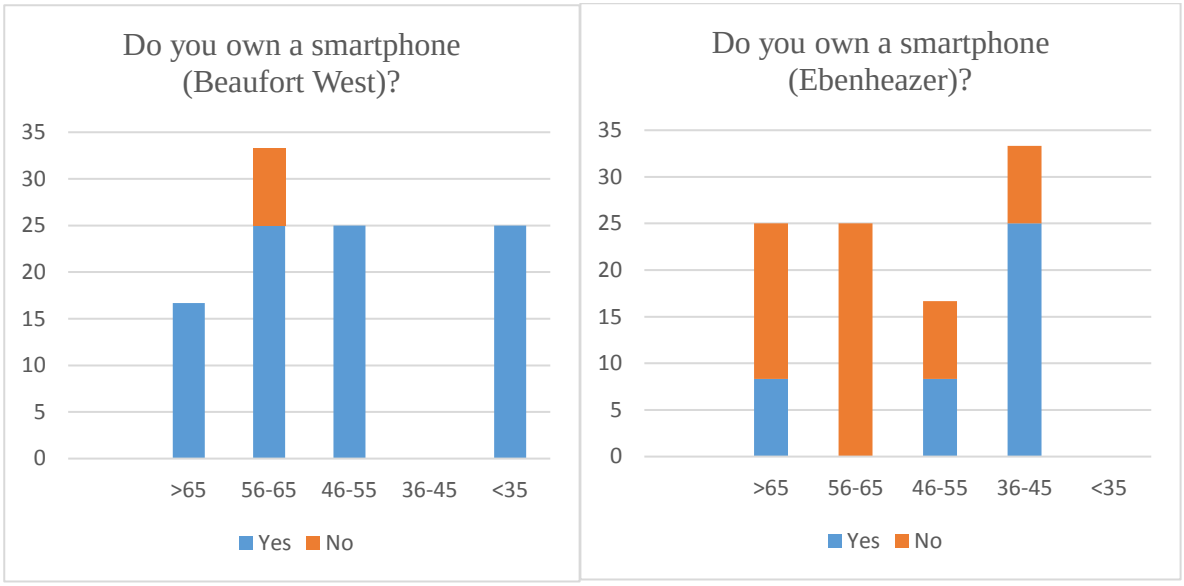

Figure 4.2: Response of the farmers' ownership (in %) of a smartphone in Beaufort West and Ebenheazer communities respectively

4.3.1.2. Challenges of accessing information

During the interviews, the majority of farmers in Ebenheazer community did not own a smartphone (Figure 4.2). The respondents indicated that poor and no internet access are some of the reasons they did not favour owning a smartphone. There was no association between the age of the farmer and owning a smartphone (Table 4.2) but there was high association of challenges of accessing information and the age (odds ratio of 2.852), gender (1.01), level of education (0.76) and the district (1.00) of the farmers. The results indicated that as the age of the farmer increases, the harder it was for older farmers to have easy access to information.

Table 4.2: The odds ratio table for checking the association of Age and the source of information variables

Variable	**Odds Ratio**			
	Age	Gender	Level of education	District
Willingness to use a database	3.66	1.22	1.68	1.00
Source of information	1.15	0.94	1.13	1.00
Challenges of accessing information	2.85	1.01	0.76	1.00
Own a Smartphone/Computer	0.33	1.10	1.06	1.00

Moreover, the geographical location of farmers affected them with issues of connectivity due to poor or no internet access. Similarly, Lekopanye & Sundaram (2017), reported that livestock farmers in Ngwaketse Region in Botswana identified poor connection signal and high cost of ICT related services as hindrances towards ICT application in this region. Although majority of the respondents sourced their information from

the government extension officers (Figure 4.1), some of the farmers indicated that it was not always the case. The officers can spend about 2 to 3 months without communicating or visiting the farmers. However, one of the officers stated, "there were many farmers compared to the number of government extension officers available". This finding concurs with Lekopanye & Sundaram, (2017) who reported that respondents stated that government extension officers in Ngwaketse Region in Botswana with knowledge on livestock production and farming cannot communicate with all livestock farmers. There was an even distribution of the challenge of having access to adequate and reliable information along the smallholder sheep farmers' age groups.

4.3.2. Records and recordkeeping systems of smallholder livestock farmers

In this study, 53% of the participants kept records on livestock, health status and flock size. However, the farmers reported, "animal and farm records have not been resourceful". The farmers did not favour the method of manual recordkeeping especially the use of exercise books for recording and storage of records because the information written on paper was vulnerable to damages or being lost. This finding concurs with Mwanga et al. (2014) who highlighted that damage of books or loss of the record books were some of the challenges the farmers experienced due to traditional methods of storing information and recordkeeping. In addition, Chisango (2017) stated that traditional methods of data capturing and data storage lacked a homogenous way of managing records. Also, when using these traditional recordkeeping systems there is little room for changes or modifications on the existing data (Lekopanye and Sundaram, 2017). The development in ICTs has revolutionized the way livestock farmers practice livestock production, farm management and communication among the farmers and other related stakeholders (Munyua, 2007; The World Bank, 2011; Singh, Kumar and Singh, 2015). Livestock production management has positive effects on assessing the performance and productivity of smallholder livestock production. For example Chisango (2017) reported that ICT tools can empower smallholder farmers in making informed and reliable decisions based on new and progressive recordkeeping, and data capturing systems/tools. Also, Nyamushamba et al. (2017) reported that due to the absence of recordkeeping of animal records, animal production and productivity, the Bull Scheme was evaluated to be ineffective in the communities.

Table 4.3: Some of the factors identified by the farmers to be included in the development of a recordkeeping database

Variable	**Description**
ID	Identification number
Breed	Breed identification number
Age	The age of the sheep
BCS	The body condition score of the sheep
Mating Weight	The weight at mating of the sheep in kilogram

Referring to Table 4.3, the farmers identified the factors such as the breed of the animal as important for the farmers and needed to be included in the development of a recordkeeping database. In order to distinguish between breeds and select the animal that performs better in terms of productivity and production, the farmers identified mating weight, body condition score (BCS) and age of the sheep.

4.4. Conclusion

The results from the study clearly shows the significance of government extension officers to smallholder livestock farmers in developing countries. Poor network/internet access and unreliable electrical power are challenges affecting/impeding the use of smartphones by farmers. Poor internet access was associated with the location of the farmer whereas the age of the farmer was heavily associated with the challenge of accessing information amongst the farmers. The farmers were involved in the development of the recordkeeping web-application. They provided input on the attributes, which were of concern to the sustainable production and management of sheep. Addressing issues like poor recording of livestock records especially for smallholder farmers in developing countries could positively direct influence on sustainable sheep production. The participation of farmers in the development of such platforms such as the recordkeeping database is highly recommended and necessary.

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CHAPTER 5. Development of a recordkeeping web-application.

Abstract

This chapter focused on the development of a recordkeeping database for smallholder sheep farmers in Beaufort West and Ebenheazer communities. Poor and traditional recordkeeping methods have slowly affected the development of livestock production within smallholder livestock production. The farmers highlighted the attributes they wanted to be included in the development of the web-application. In this study, about 75% of the farmers reported that data capturing and recordkeeping were vital aspects of good livestock production and farm management. There was no association with the willingness of the farmers to use the recordkeeping database with owning a smartphone/computer, the location and gender of the farmer. The majority of the farmers favoured to have a picture on the farmer profile. The developed web-application recordkeeping database will have important functions such as editing, deleting and adding information whenever a farmer needs to.

Keywords: recordkeeping, database, farm management, livestock management

5.1. Introduction

Poor and unreliable recordkeeping methods make smallholder livestock management an important task to other stakeholders in the livestock industries. For example, Mwanga, (2014) reported that it was difficult for the government extension officers to assist farmers in need because of the lack of good and reliable recorded information. The absence of certain records whenever a farmer needed assistance affected the production output of farmers. Recordkeeping is vital for the improvement of good livestock and farm management. Records assist livestock farmers with undertaking livestock performance evaluation and executing other important farm related tasks (Abegaz et al., 2008). For the development of good quality and reliable data, it is important that all stakeholders in the livestock industry are included. Barakabitze, Fue and Sanga, (2017) reported that participatory approaches were successful in Tanzania mainly for implementation and use of Information and Communication Technologies (ICTs) by farmers. Moreover, in modern day farming, smallholder farmers have access to a smartphone. A smartphone is not only for making voice calls but also has and performs some additional features and functions respectively. A recordkeeping web-application for smallholder sheep farmers' in the Ebenheazer and Beaufort West allows farmers to record, edit and store farm and livestock web-application. As smartphone, technology continues to create new opportunities for improvement of farm operations management in smallholder farms (Lantzos, 2013), using a smartphone or computer as a tool to store on-farm records is important and significant. In addition, smallholder livestock farmers can minimise the damage of records stored in an exercise book or written paper.

The design and development of the format of the web-application should be simple, user-friendly and easily understood particularly by the farmers and other stakeholders. Lately, there have been demands from the customers to warrant the safety in the livestock industry**.** Hence, the development of tools like the web-application for recordkeeping can ensure farmers to trace-back related animals using the pedigree information recorded throughout the farming seasons. In order to achieve success in livestock production, Kosgey et al., (2006) recommended other stakeholders to have a holistic view on the smallholder livestock production system and include the farmer in every stage of planning and running of the breeding programme. Moreover, Gizaw et al., (2014)reported that uncontrolled mating increased due to decrease in the participation of farmers. Regardless of the significance of farm records to the development of livestock production within smallholder livestock farmers, the farmers often consider it as a demanding job. However, Devonish, (2000), found that smallholder farmers who did not keep or maintain records stated time as the limiting factor. Moreover, the farmers who did not have records for their livestock found it difficult to access credit. There are certain factors affecting smallholder livestock farmers to record and keep records. According to Devonish, Pemberton and Ragbir, (2000), the keeping of records by farmers was independent to age, gender and level of formal education. However, recordkeeping was heavily dependent on the size of the farm and farmer status. According to Abegaz et al., (2008), farmers need to keep records that had the values and relevance to different types of

sheep and goat production systems. Some of the attributes suggested by the author include lambing records, which include the animal identification (ID), date of birth, feed consumption, and health records.

5.2. Materials and Methods

5.2.1. Study site and farmer selection

The site of study, selection of the farmers and the data collection time is outlined in Chapter 3 section 3.1.

5.2.2. Data Collection

A survey questionnaire and focus group discussions were used during data collection. The information reported and analysed in this chapter include the design and development of a recordkeeping database, and the farmers' perceptions on use and integration of ICTs in smallholder sheep farming systems. In addition, the farmers ranked how a recordkeeping database can assist them with data capturing and recording, issues of traceability, networking with other farmers and stakeholders. The data collected included the response from farmers and the information/variables farmers wanted to be included in the development of a recordkeeping database.

5.2.3. Data analysis

To analyse the data RStudio was used to perform a logistic regression to check whether there was an association between the willingness of the farmers to use the recordkeeping database and other variables such as age, gender, and district. The analysis also included the information obtained from focus group discussions. The analysis indicated the appropriate statistical measures (summary statistics).

5.2.4. Design and development of the recordkeeping database system.

Firstly, there was identification of the basic standards of a good sheep recording system in developing the recordkeeping database. Additionally, the development of the recordkeeping application took into consideration the limited amount of time that a smallholder farmer has. The objective was not to burden the farmers with complex and difficult recording system, which is hard to understand and use. The recorded information should allow the farmer to make decisions or take actions on sustainable livestock production, farm management and improvement of sheep farming (Jeyabalan, 2010). Otherwise, the recordkeeping database system is not useful. Go programming language was the software used to develop a recordkeeping management software implemented in this study. The application still under development will serve as a website, a management system, and client accounts management interface and an administrative console. The data structure of the application is composed of models and relations may exist between the models where an ID of one model is an attribute in another model. Models in this study represents tables with attributes stored

in columns and records stored in rows. Every record (or row) in the model has an ID that uniquely identifies it. The data operation described assists in viewing and manipulating the models data.

Farmers were asked in a focus group discussion on what type of information they want to be captured in the application. The farmers were divided into two groups in both communities (Ebenheazer and Beaufort West). According to farmer 1 in Ebenheazer, "the development of a recordkeeping database can assist farmers with managing livestock herds". The farmer indicated factors like sheep health: flock size and feed as important aspects to his sheep production system. Again, in Ebenheazer farmer three and five said, "The database creates opportunities for improved sheep breeding and information is safer when it is stored online compared to paper". The farmers also highlighted how information such as date of birth of the animal, number of lambs born and died were important in choosing the best animals to keep on the farm. "The recordkeeping application can assist farmers in storing data and information for a longer time than records kept on paper," said farmer 1 in Beaufort West. The farmer further highlighted that farmers did not favour storing/keeping of livestock records on paper. However, farmer 3 said, "The database can only help if he can understand it". The farmers in Beaufort West highlighted the importance of different breeds kept for smallholder sheep farming in their community. They indicated how the recording of sheep breeds was important for development of sheep production. Figure 5.1 shows the steps followed when developing the web-application database and Table 5.1 gives the information on the web-application models included in the development of the recordkeeping database.

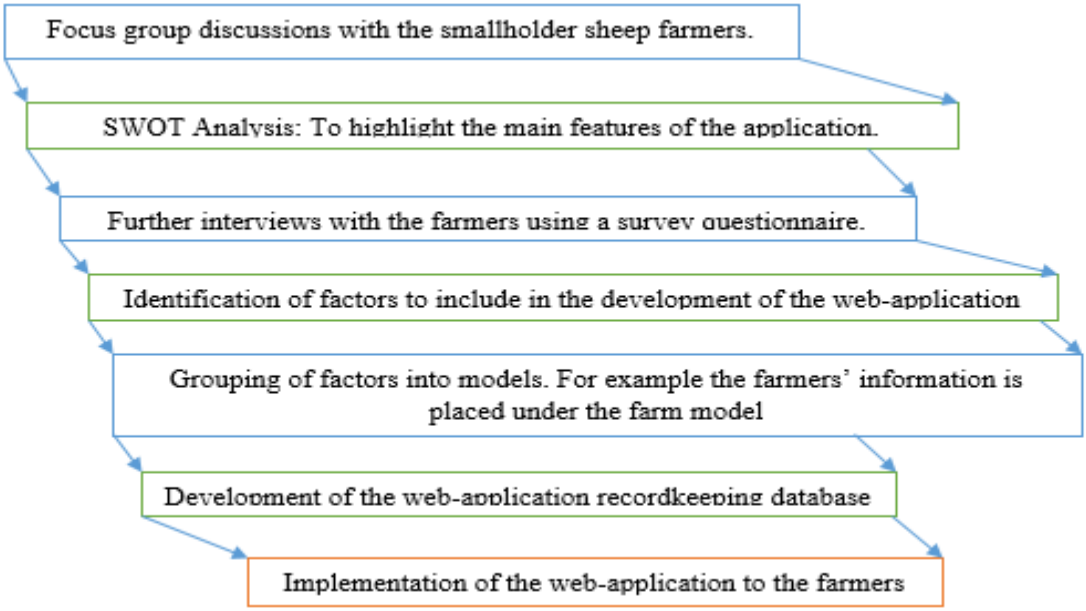

Figure 5.1: The steps followed/taken in the study to develop the web-application for recordkeeping for smallholder sheep farmers in Ebenheazer and Beaufort West communities.

The application consists of four main models, which are Farms, Breed, Rainfall and Sheep. The Farm model describes farm and farmer data; the Breed model describes the sheep breed data. Each record describes a breed of sheep with its amounts and health practices and each breed related to a farm. The Rainfall model describes the rainfall amount per day. Lastly, the Sheep model describes the sheep performance data. Each record describes a specific sheep that relates to a breed, together with its performance data. Table 5.1 shows an example of the sheep model and the type of information a farmer can add.

Table 5.2: The layout of the sheep model with different attributes of information added to the application

Attribute	**Description**	**Data Type**	**Example**
ID	Identification number	uint	123
BreedID	Breed identification number	uint	123
Age	The age of the sheep	uint	123
BCS	The body condition score of the sheep	uint	12
MatingWeight	The weight at mating of the sheep in kilogram	float	56.7
NumberLambs	The number of lambs born to the sheep	uint	1

The type of data operations performed on the application include:

1. To add, update and remove operations of farms
2. Listing of farms
3. Sorting the list of farms by location, gender of farmer and education level of farmer
4. Viewing individual farms with a list of related breeds
5. Viewing individual breeds with a list of related sheep
6. Adding, updating and removing rainfall data on farm
7. Adding, updating and removing breeds on farm
8. Adding, updating and removing sheep of a breed
9. Display sheep averages in a certain location
10. Display the average for sheep per farm size

5.3. Results and Discussion

5.3.1. Farm model

Farmer Model provide the farm setup related services such as those needed to register the farmer on the web application. The design of the application included a series of user-friendly menus, which simplify the process of data entry. There is connection between these menus to facilitate changes between the types of information, which is recorded, edited or stored. Figure 5.2 shows the display of the welcoming page of the application. In the Farmer module, the farmer can add information about the farm such as the location of the farm, and the

demographic information of the farmer. The farmer is able to edit, delete and save the information whenever there is new information to add. After adding the location coordinates, the location automatically highlights on the Map in the user interface.

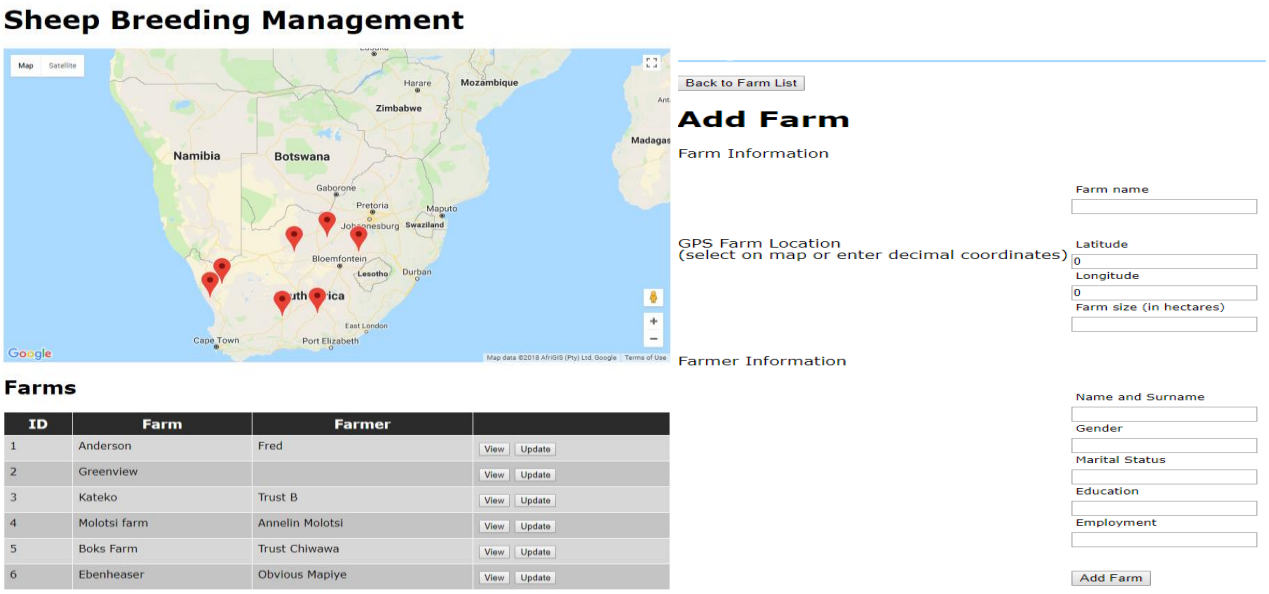

Figure 5.2: The display of the web-application main page.

5.3.2. Sheep model

After registering, the farmer proceeds to add information of the sheep on the farm. The sheep model will include the sheep ID, age, and body condition score. The farmer can edit these variables including the mating weight of the sheep and the number of lambs born anytime if there is something to add. In addition, there is a relationship between the sheep and breed models because multiple sheep have a relationship within a single breed.

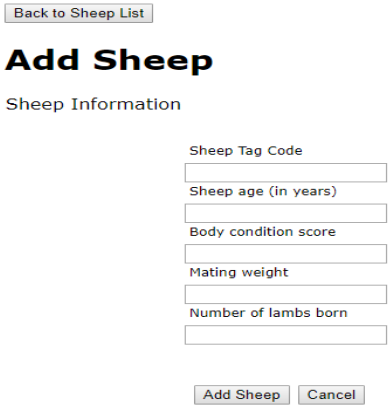

Figure 5.3: Menu display of the page where the farmer add information such as the weight, age and lambs born.

5.3.3. Breed model

Figure 5.4 shows the display of the breed model interface. The farmer develops a profile for the sheep they have in terms of the breed. The model allows the farmer to add information on how many rams, ewes, and lambs of a certain breed they have including the age of the sheep. An example such as Serabu shown below.

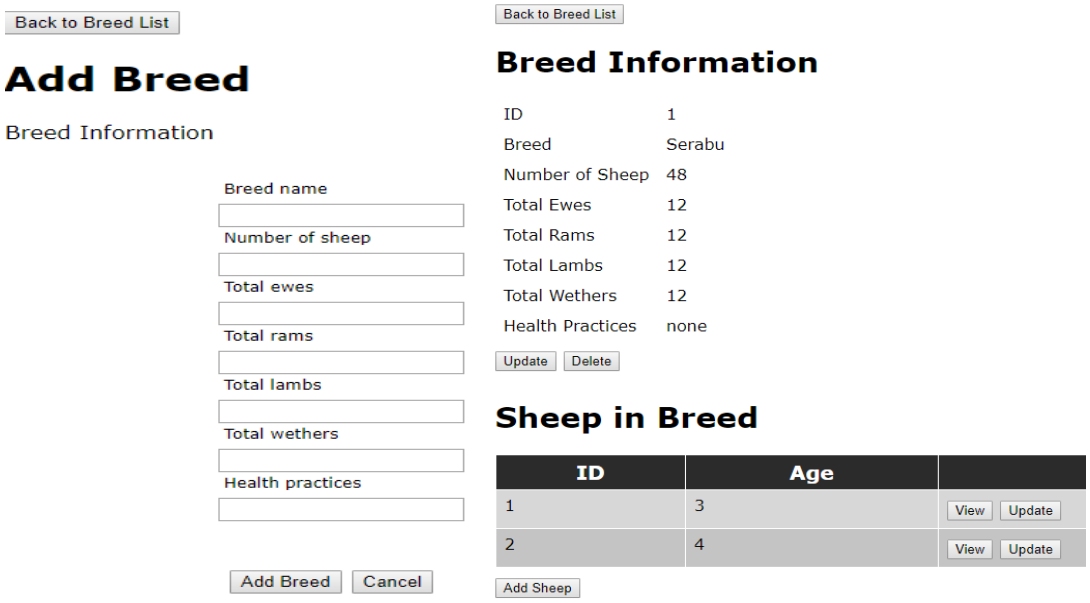

Figure 5.4: The breed input page where a farmer add, edit and delete the information on sheep breeds on the farm.

5.3.4. Rainfall model

The rainfall model is for the farmer to keep up to date with the exact dates when it rains. The model only consists of two variables, which is the date of raining and the amount of rainfall received in millimetres.

Figure 5.5: Display of the rainfall model.

The information is stored in a database after the farmer finishes adding the information. The farmer can have access to the information anytime and anywhere. The farmer will be asked to enter log in details whenever they want to have access to the information on the database. This is done for protecting the information of the farmer.

5.3.5. The response of the farmers on the recordkeeping database.

About 80% of the participants in Beaufort West had knowledge of what is a recordkeeping database while in Ebenheazer about 40% reported so. The farmers asked where asked whether they have heard about or seen a recordkeeping the database, the majority of the farmers reported that it was through workshops and contact sessions. The workshops involved different stakeholders who assisted the farmers with answering questions pertaining to what was a recordkeeping database, the benefits and challenges.

Table 5.3: The number of respondents with knowledge of what is a recordkeeping database in percentage.

	Yes (%)	No (%)
Ebenheazer	41.7	58.3
Beaufort West	83.3	16.7

The results showed that farmers in Beaufort West were more knowledgeable on what is a recordkeeping database as compared to the farmers in Ebenheazer. The observation from the study was that farmers in Beaufort West had access to internet and did make use of the internet services than farmers in Ebenheazer who did not have internet access on regular basis. This observation concurs with (Babu and Asokhan, 2010) who stated that there existed an association between the little use and awareness of ICT related services with the level of education the participants. Farmers in Ebenheazer and Beaufort West communities are responsible for the recording of information on the farm. From the study, there was no association between the farmers' willingness to use the recordkeeping application with factors like gender and location of the farmer. However, there was a relationship between the age of the farmer and the willingness to use a recordkeeping database. The younger the farmer the more a farmer was interested in using the application

5.3.6. The importance of a recordkeeping database within smallholder sheep farmers.

The results presented in Figure 5.6 and Figure 5.7 indicates the farmer's response on to what extent the database can assist the farmers with networking with other farmers, communication with stakeholders, issues of traceability, sharing of information, data capturing and recordkeeping. In Beaufort West 75% of the farmers ranked the extent 'high' of improving data capturing and recordkeeping using the recordkeeping web-application software. The farmers reported that the application could reduce the gap of sharing of information with about 67% ranking the extent 'high', traceability (58%) and communication with stakeholders (50%).

However, they indicated that it would moderately assist them with networking with other farmers with 67% of the farmers ranking the extent ‘medium’.

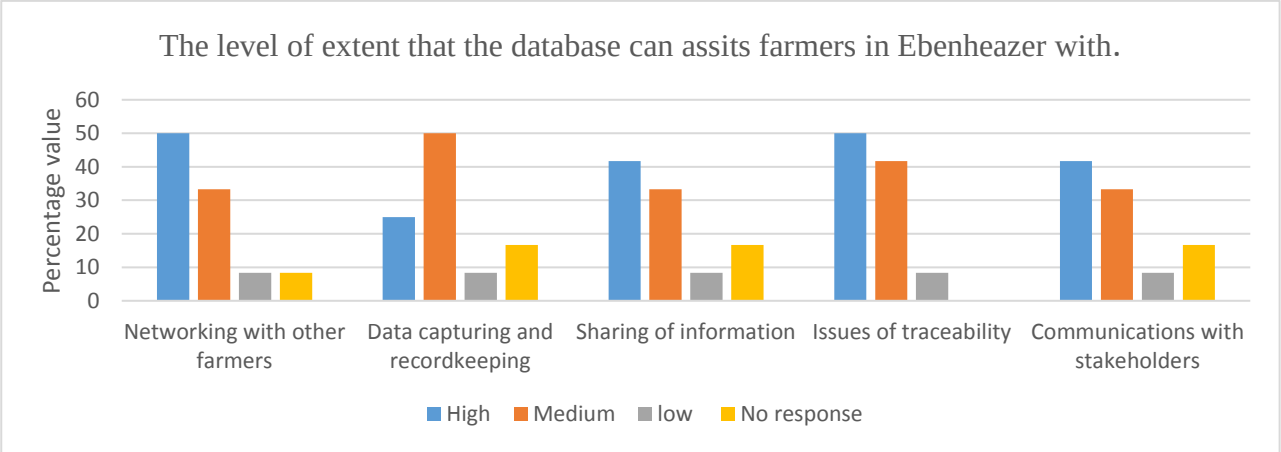

Figure 5.6: The response of the farmers when asked to what extent the database will assist in networking with others and recordkeeping in Ebenheazer

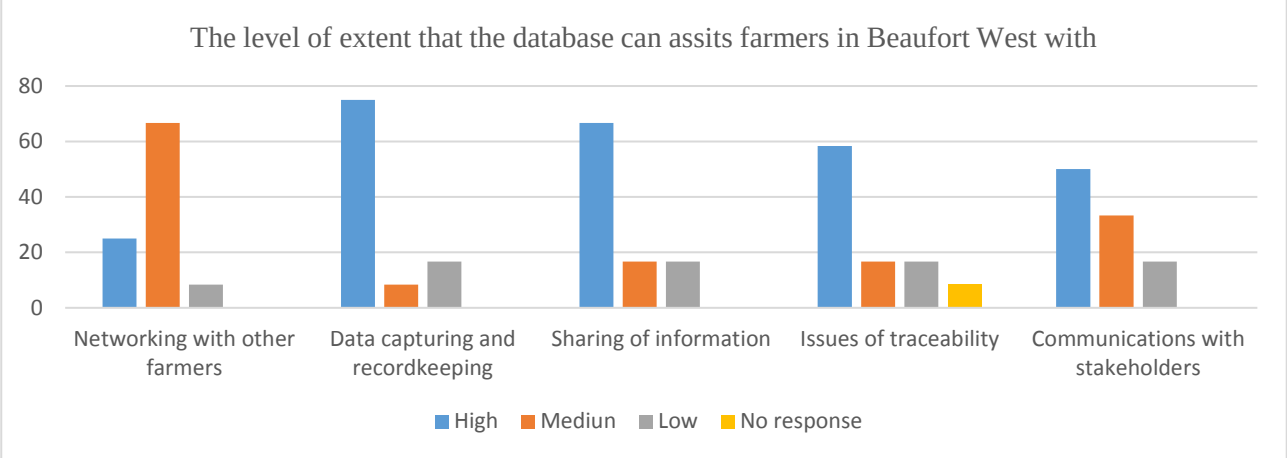

Figure 5.7: The response of the farmers when asked to what extent the database will assist in networking with others and recordkeeping in Beaufort West.

In Beaufort West 75% of the farmers ranked the extent ‘high’ of improving data capturing and recordkeeping using the recordkeeping web-application software. The farmers reported that the application could reduce the gap of sharing of information with about 67% ranking the extent ‘high’, traceability (58%) and communication with stakeholders (50%). However, they indicated that it would moderately assist them with networking with other farmers with 67% of the farmers ranking the extent ‘medium’. In Ebenheazer, the farmers’ responses were diverse. With 50% of the farmers ranking the extent level to which the web-application can assist with data capturing and recordkeeping ‘medium’. It was indicated that networking with other farmers (50%), sharing of information (41%), and communication with stakeholders (41%) were the issues the web application software can assist the farmers. With the farmers, ranking the level of extent the application can assist ‘medium’. The farmers had to identify some of the possible challenges that can affect or occur when using the

web-application software for recordkeeping. The farmers highlighted a few challenges such as network for the smartphone, not having data and power cuts. These challenges according to the farmers can reduce the adoption and use of the web application by the farmers. Additionally, Chisango (2017) stated that farmers highlighted unreliable electricity supply as one of the variables signifying the weak adoption of ICTs by the farmers.

5.4. Conclusion

The findings in this study clearly shows the significance of recordkeeping in smallholder sheep farming systems. However, the perceptions and readiness of farmers to support the development and implementation of the recordkeeping management system are moderate. The farmers highlighted poor network/internet access and unreliable electrical power as two of the major challenges that can hinder the use of the web-application. Poor internet access was associated with the location of the farmer. In addition, the majority of the farmers owned a smartphone. The farmers were involved in the development of the recordkeeping web-application. They provided input on the attributes, which were of concern to the sustainable production and management of sheep.

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CHAPTER 6. Conclusions and Recommendations

6.1 General Discussion

The objective of this study was to design and develop a recordkeeping database for smallholder sheep farmers in Beaufort West and Ebenheazer communities. The database can assist farmers with recordkeeping and contributes to the sustainability of sheep production and alleviation of poor recordkeeping methods. The development of the database was through the active participation of both stakeholders involved such as farmers and student. In addition, farmers highlighted the constraints affecting the environment and their socio-economic livelihood.

The objective of CHAPTER 3 was to recognize and categorize the challenges and the benefits associated with manual data capturing, incorporating ICTs in livestock (sheep) data management and recordkeeping by smallholder sheep farmers in Beaufort West, and Ebenheazer. The response from the farmers highlighted that the use of pen and paper for recording and recordkeeping was time consuming and tiring. The challenges and problems of smallholder sheep farmers were identified. The challenges were categorized into ecological and socio-economic challenges. The challenges identified by the farmers include, drought, lack of feed and water. Through SWOT analysis, the farmers identified the strength, weaknesses, opportunities and threats. Mapiye, (2017), reported that creating a platform for farmers to add and share information can improve positively the sustainable production of sheep. Thus from this study it can be concluded that interventions to improve the sustainability of smallholder sheep farmers in both communities are wanted. These interventions should focus more on the farmers taking part in research studies.

The objective of CHAPTER 4 was to assess the smallholder's perceptions and willingness to support the web application additional development in South Africa. The results highlighted that there was no relationship concerning the willingness of the farmer to use the web-application with, gender, location and source of information. However, there was association between the age of the farmer and the willingness to use a recordkeeping database. The younger the farmer the more a farmer was interested in using the application. The farmers accessed more information through government extension officers for both communities. In this study, about half of the participants kept records on livestock, health status and flock size. However, the farmers reported, "animal and farm records have not been resourceful". The farmers were against the method of manual recordkeeping especially the use of exercise books for recording and storage of records because the information written on paper was vulnerable to damages or being lost. Poor network access and unreliable electrical power are challenges affecting/impeding the use of smartphones by farmers. Poor internet access was associated with the location of the farmer whereas the age of the farmer was heavily associated with the challenge of accessing information amongst the farmers. The farmers were involved in the development of the recordkeeping web-application. They provided input on the attributes, which were of concern to the sustainable production and management of sheep

CHAPTER 5 involved the development of a recordkeeping database. Go programming language was the software used to develop a recordkeeping management software implemented in this study. The application still under development will serve as a website, a management system, and client accounts management interface and an administrative console. The results showed that farmers in Beaufort West were more knowledgeable on what is a recordkeeping database as compared to the farmers in Ebenheazer. Moreover, the geographical location of farmers affected them with issues of connectivity due to poor or no internet access. This observation concurs with Munyua (2007), who stated that poor infrastructure, ICT skills and poor network connection are some of the drivers preventing ICTs use in agriculture. The response of the farmers when asked to what extent the database can assist the farmers with networking with other farmers, communication with stakeholders, issues of traceability, sharing of information, data capturing and recordkeeping. The majority of the farmers expressed their willingness to use the recordkeeping web-application database as soon as it is finished developing. The analysis of the results showed that there was no influence from the location of the farmer, and source of income on the willingness of the farmers to use the web-application.

6.2 **Conclusions**

The information obtained in this study clearly shows that sheep production is an asset for the improvement of smallholder sheep farmers' livelihoods in the Western Cape Province, South Africa. To achieve better production and productivity requires better knowledge of the problems disturbing the development of smallholder sheep farming. Results from the study shows that sheep farmers in the Western Cape faces many challenges. These problems include poor internet access, poor network connectivity and unreliable electricity supply from Eskom. The farmers assisted in the design and development of a recordkeeping web-application. The farmers indicated the features they wanted to be included in the design and development. However, the farmers also highlighted the obstacles that can affect the adoption and use of tools like an online recordkeeping system. The results from this study shows that smallholder sheep farmers in Beaufort West and Ebenheazer face other challenges such as the environmental and socio-economic challenges. The problems include drought, lack of feed, water shortages, pests, diseases and predation. In order to mitigate such problems, the farmers sourced information from mostly the government extension officers. However, an encouragement to farmers on using the web-application database need to be encouraged and supported.

6.3 **Recommendations**

Results of this study suggest that it is significant to include farmers when making decisions that affect the production of sheep especially among smallholder farmers in developing countries. To improve the problems affecting smallholder farmers' improved communication and the use of a recordkeeping database is encouraged. It is recommended to always include the farmers in participating in the research. The farmers are known to provide reliable and adequate first-hand information. This is meant to improve the interaction and

participation relationship between the farmers and other stakeholders. In future, the development of a recordkeeping database will include more features as to the needs of the farmers. In this regard, I recommended that:

1. Always include the farmers in making decisions on the features to add when developing the web-application.
2. The government extension officers need to be equipped with skills and tools to ensure constant support to farmers.
3. Farmers must take note and select the animals that are performing better and well in terms of adapting to harsh environments pests and diseases.
4. Lastly, the farmers need to maintain reliable and adequate records.

6.4 Future suggestions for further studies

The study provided the information on the design and development of a recordkeeping database for smallholder sheep farmers in the Western Cape Province. Hence, further studies are required to:

a. Implement the web-application recordkeeping database to smallholder sheep farmers in the Western Cape Province
b. How effective and resourceful is the database?
c. Implement how the developed database can be in other farming systems, which are not only for sheep farming.

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