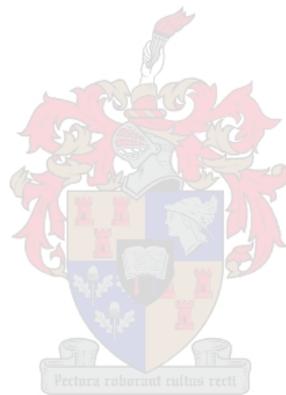


Adoption of ICT by sheep farmers in the Western Cape (Karoo and Eden): Towards sustainable farming

by

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Thesis presented in partial fulfilment of the requirements for the degree of **Master of Science in Sustainable Agriculture** in the Faculty of AgriSciences at Stellenbosch University

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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

Sustainable livestock production refers to the rearing of livestock in agricultural systems that are more natural and can be sustained over a long period. Food markets, particularly sheep products, are becoming more globalized, making buyers more concerned about the origins of the food they consume. The study aimed to determine the use of Information and Computer Technologies (ICT) to encourage sheep farmers to record data. The study's main objective was to assist smallholder sheep farmers in using a Sheep Breeding Management (record-keeping application) by determining the factors that influence the adoption and willingness to use ICTs by sheep farmers in the Western Cape. This was achieved by administering structured questionnaires to farmers in the Western Cape (Eden and Karoo districts). Fifty-three farmers participated in the research study. Challenges and opportunities associated with adopting a Sheep Breeding Management application (record-keeping application) were identified. A quantitative research approach was used in the study, and data were analyzed using descriptive statistics. There was no association between age and district from Chi-square analysis ($p = 0.67$). Age plays a role in farm growth and the availability of information. Of these participants, 60.38 % were aged 55 years and above with a mean of 63.8 ± 1.43 . At the same time, about 39.62 % were aged below 55, with a mean of 44.3 ± 1.4 . Sheep farmers in Eden within the age range of 50-59 years own a significant number of sheep with an average of 132.5 ± 36.4 of the sheep flock. Sheep numbers are higher in the Eden district, with an average of 370.8 ± 94.3 than Karoo (180.2 ± 38.9). Age, level of familiarity, and education level are less likely to affect the willingness to adopt the record-keeping application. The majority of the farmers (60%) are into conventional sheep farming, and 23.1% using the pastoral sheep farming system. Approximately 79% of the smallholder sheep farmers interviewed in the Karoo and Eden districts (representing semi-arid environments) were willing to adopt and use the record-keeping application. The record-keeping application will help sheep farmers in the process of certification to organic or Karoo sheep farming. Twelve percent of the farmers are currently Karoo lamb certified, and 4.9% are certified organic sheep producers. The farmers emphasized that it was time costly to use pen and paper for record-keeping, and forgetfulness using individual memory leads to poor farm records. At the same time, it is expensive to purchase record-keeping applications and devices. Record-keeping is a valuable way for all sheep farmers to improve production, market and resource management and sustainability. Smallholder sheep farmers will enter the niche market of organic and Karoo meat of origin when traceability systems are in place through ICT use for record-keeping. Adopting ICTs by smallholder sheep farmers (The Sheep Breeding Management application) allows for quality control on sheep farms and better management decisions by smallholder sheep farmers.

Keywords: record-keeping, adoption, smallholder sheep production, Karoo lamb, organic sheep farming

OPSOMMING

Volhoubare veeproduksie verwys na die grootmaak van vee in landbousisteme wat natuurliker is en oor 'n lang tydperk volgehou kan word. Voedselmarkte, veral skaapprodukte, word meer geglobaliseer, wat kopers meer bekommerd maak oor die oorsprong van die voedsel wat hulle verbruik. Die studie het ten doel gehad om die gebruik van inligting- en rekenaartegnologieë (IKT) te bepaal om skaapboere aan te moedig om data op te neem. Die hoofdoel van die studie was om kleinskaapboere te help om 'n skaapteeltbestuur te gebruik (rekordhouding) deur die faktore te bepaal wat die aanneming en bereidwilligheid om skaapboere in die Wes-Kaap te gebruik en IKT's te beïnvloed. Dit is bereik deur gestruktureerde vraelyste aan boere in die Wes-Kaap (distrikte Eden en Karoo) in te dien. Drie-en-vyftig boere het aan die navorsingstudie deelgeneem. Uitdagings en geleenthede verbonde aan die aanneming van 'n aansoek vir die bestuur van skaapteelt (rekordhouding) is geïdentifiseer. 'N Kwantitatiewe navorsingsbenadering is in die studie gebruik en data is met behulp van beskrywende statistieke geanaliseer. Daar was geen verband tussen ouderdom en distrik van Chi-kwadraat-analise nie ($p = 0.67$). Ouderdom speel 'n rol in plaasgroei en die beskikbaarheid van inligting. Van hierdie deelnemers was 60.38%, 55 jaar en ouer met 'n gemiddeld van 63.8 ± 1.43 . Terselfdertyd was ongeveer 39.62% onder 55 jaar oud, met 'n gemiddelde van 44.3 ± 1.4 . Skaapboere in Eden binne die ouderdomsgroep 50-59 jaar besit 'n beduidende aantal skape met gemiddeld 132.5 ± 36.4 van die skaapkudde. Die skaapgetalle is hoër in die Eden-distrik, met gemiddeld 370.8 ± 94.3 as Karoo (180.2 ± 38.9). Ouderdom, vlak van bekendheid en opleidingsvlak beïnvloed minder die bereidwilligheid om die rekordhouding-aansoek aan te neem. Die meeste boere (60%) is besig met konvensionele skaapboerdery, en 23.1% gebruik die pastorale skaapboerderystelsel. Ongeveer 79% van die kleinboer-skaapboere wat in die Karoo- en Eden-distrikte ondervra is (wat halfdroë omgewings verteenwoordig) was bereid om die rekordhouding-toepassing aan te neem en te gebruik. Die aansoek om rekordhouding sal skaapboere help in die proses van sertifisering vir organiese of Karoo-skaapboerdery. Twaalf persent van die boere is tans Karoo-lam gesertifiseer, en 4.9% is gesertifiseerde organiese skaapproducente. Die boere het benadruk dat dit duur is om pen en papier vir rekordhouding te gebruik, en vergeetagtigheid deur individuele geheue te gebruik, lei tot swak plaasrekords. Terselfdertyd is dit duur om aantekeningtoepassings en toestelle aan te skaf. Rekordhouding is 'n waardevolle manier vir alle skaapboere om produksie, mark- en hulpbronbestuur en volhoubaarheid te verbeter. Kleinboer-skaapboere sal die nismark van organiese vleis en Karoo-vleis van oorsprong betree wanneer naspeurbaarheidstelsels bestaan deur middel van IKT-gebruik vir rekordhouding. Die aanvaarding van

IKT's deur kleinskaapboere (The Sheep Breeding Management application) maak voorsiening vir gehaltebeheer op skaapboerderye en beter bestuursbesluite deur kleinveesboere.

Trefwoorde: rekordhouding, aanneming, kleinskaapproduksie, Karoo-lam, organiese skaapboerdery

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CHAPTER 1

1.1 Introduction

Sustainable livestock production refers to the breeding of livestock in agricultural systems that are more natural and can be sustained over long periods to ensure food security, with the use of low inputs and at the same time focusing on the social, ecological and economic facets of sustainability (AgriSETA, 2018). Sustainable sheep farming is based on farming practices that preserve the environment and, at the same time, give back profits and productivity on land for the farm (Dudafa, 2013). Sheep farming in South Africa is predominantly practised in large pastoral areas where no other farming projects are feasible, such as the vast Karoo regions of the country's central region, which align with sustainable farming (Kirsten, Jordaan & Van Der Merwe, 2013; Molotsi, 2017). Meat produced under the Karoo region has been marketed as Karoo lamb of origin (Kirsten, Jordaan & Van Der Merwe, no date; Van der Merwe, Kirsten & Trienekens, 2017). These farming systems with low production inputs are aligned with organic farming principles. Sheep farming is the most dominant industry in the dry western and central districts, covering up to 50.8% of the region's total area (AGIS, 2007e). Sheep farming is also used to supplement crop production in low-rainfall areas, with sheep consuming crop residues and by-products from preferred ley farming systems. Farmers also depend on sheep farming to provide livelihoods for the families and workers in years of crop failure due to drought and diseases and in times of unstable grain prices. South African sheep farmers face various challenges, including diseases, lack of proper breeding records, adoption of modern technologies and insufficient resources, and these problems create severe limitations to production (Myeni *et al.*, 2019). On the other hand, sheep farmers need accurate pedigree and animal performance records, which assist in the collection of accurate animal genotype records that are consistent with the environment. (Molotsi, 2017). Record-keeping is also vital for traceability purposes if the farmers are certified as organic or Karoo lamb.

Food markets, particularly sheep products, are becoming more globalized, making consumers more concerned about their food origins to gain confidence in food quality and safety (Tijjani *et al.*, 2017). The main goal of introducing ICT based technologies lies in the traceability of products as it is easier to keep all the information in one place (Chiwawa, 2019). Traceability systems address these concerns, and the link between the product, producer and consumer has become a matter of importance in the livestock sector (Montossi *et al.*, 2013). Traceability is described as maintaining credible custody through various food chain steps from farm to vendor to identify animals. Traceability of food products consists of developing an information trail (Smith *et al.*, 2005). Traceability in the meat industry includes the ability to classify

an animal, trace its lifespan and trace its meat products to the ultimate consumer. Smith *et al.* (2005) identified traceability goals for food and risk management, food safety, inspection, testing, product quality assurance, customer information, and communication. Things regarding traceability are also part of product attributes that affect consumers' decision to buy Karoo and organic lamb (Du Plessis & Du Rand, 2012).

The Karoo lamb has a unique taste and is lamb meat specifically raised within the Karoo region of South Africa. (Cloete & Olivier, 2012a; Van der Merwe, Kirsten & Trienekens, 2018). "Organic" involves the production of crops or livestock in a way that constructs the soil and improves biodiversity and the climate. (Myeni *et al.*, 2019). Organic sheep farming is based on pasture and needs little to no additional feeds, which decreases the energy required for feeding from source to flock. The feed for sheep is 100% certified organically (including pasture) with the prohibition on the use of medicines or hormones. The products are processed in a certain way and not irradiated (Hale *et al.*, 2010). The lack of certification causes uncertainty about whether the product comes from the Karoo or is organic. Traceability is a method used to check the genuineness and claims of producers (Hale *et al.*, 2010). Due to sheep farmers' current farming practices in South Africa's extensive areas, production could be easily classified as organic or Karoo lamb (if the farm is situated in the Karoo region). However, most farmers are not aware that their practices could be certified as organic or Karoo lamb, and another limitation is that these farmers do not keep detailed records of their practices (Chiwawa, 2019). Keeping records allows for proper traceability measures to be taken, and smallholder sheep farmers can be certified as organic or Karoo lamb farmers, which could result in a higher price for their products.

According to Hazell *et al.* (2010), maintaining records of animal production helps track progress and advise future farm management decisions. It is of no use to preserve documentation without reviewing or comparing findings (Chiyangwa, 2018). Comparing farm records with farmers over the years can be a valuable method for stimulating peer learning and enhancing veld management. Record-keeping is also vital for health monitoring and farm productivity evaluation (Thompson *et al.*, 2007; Chiyangwa, 2018). Integration of Information and Computer Technologies (ICTs), including hardware, software, networking, wireless, computer systems, internet access systems, mailing systems, servers, video conferencing and ICT infrastructure managing and running human capacity, are important record-keeping tools for sheep farmers. Traceability of sheep products is made successful by information and computer technology since formal monitoring for sheep farmers in the Karoo area of South Africa is not in place. (Ryde *et al.*, 1984; Nardone *et al.*, 2004; Department of Agriculture, 2011). It is essential to obtain records of growth and reproduction of sheep kept by smallholders farmers to develop sustainable breeding plans to improve their production performance and traceability purposes (Archer, 2000).

1.2 Problem Statement

Smallholder sheep farmers in South Africa has been reported to have low offtake rates (Molotsi *et al.*, 2019a). These farmers also experience market-access challenges and getting a reasonable price for their meat products. This results in lower income for smallholder farmers and the economic unsustainability of the farming system. From a previous study by Chiwawa (2019), approximately 80% of Beaufort West farmers knew what record-keeping software is. Farmers also indicated they have seen the record-keeping applications and heard about them via workshops and contact sessions. (Chiwawa, 2019). Farmers with no expertise and management experience are vulnerable to South African sheep farming and marketing's difficulties and challenges. This inevitably affects sustainability and its food security contribution to smallholder and commercial sheep farming. (Mapiye, 2017).

Sheep farmers in South Africa, particularly the Karoo region, are still using traditional record-keeping methods (hand-kept ledgers, papers and books) or not at all. These can be easily discarded or destroyed and thereby puts the farmer at risk of encountering challenges and limitations affecting the production and traceability of sheep and its products (Archer, 2000). In future initiatives to transform agricultural research and production, ICT has an important role in agricultural development (FAO, 2013). The awareness and interpretation of sheep farmers do not follow registration proposals appears to be a gap, especially in Western Cape (Mapiye, 2017; Chiwawa, 2019). Using ICTs, such as web-based knowledge management tools (for example, record-keeping applications), can help boost farmers' ability to tackle challenges and constraints towards record-keeping (Mapiye, 2017). Having proper records in place give rise to efficient farm management and helps the farmer understand how and where production is. Record-keeping and sound data interpretation also help define the farm's weakest links, which farmers can work on and increase income levels (Arzeno, 2004).

1.3 Justification

The challenges and constraints sheep farmers face can be addressed by assisting farmers to improve their management practices. Moreover, using a record-keeping application within sheep farmers eliminates their ability to rely on memory. According to Scholtz *et al.* (2013), sustainable livestock production will be slow for particular livestock traits if no proper livestock records and measurements are recorded. This is made possible by encouraging farmers to keep production records. Farmers should likewise track animals' essential records, such as breeding dates, flock illnesses, routine immunizations, and sales from selling animals to the market. Accredited markets ultimately require the mentioned records for tracing purposes (Nardone *et al.*, 2004). Subsequently, utilizing a record-keeping application to record this data will also

contribute to improvements in productivity and having the necessary information in one application will make it simpler to get verification.

Sheep farmers can further use the record-keeping application to exchange information on market prices and advise on treating diseases. A record-keeping application also helps set a benchmark for farmers to evaluate their management practices to ensure the Karoo or organic sheep farming principles are followed. For the improvement of record and research processes for sustainable animal production, it is important to keep a record for sheep farmers. When entered and kept well, records can identify the best and least-suitable management activity by farmers and other stakeholders and identify farmers who can be certified sheep farmers (Hazell *et al.*, 2010). Proper records will enable sheep farmers to enter the niche and more formal markets for a better price for their products.

1.4 Aim and objectives of the study

This study aimed to assist sheep farmers in ensuring sustainable sheep production using a Sheep Breeding Management (record-keeping application). Achievable through determining factors that influence the adoption and willingness to use ICTs by sheep farmers in the Western Cape.

1.5 Objectives

1. To determine the demographics and farming systems currently implemented by smallholder sheep farmers in the Karoo and Eden regions of the Western Cape.
2. To determine the perceptions of farmers on the use of a record-keeping application following the demonstration.
3. To determine the factors that influence adoption/non-adoption of ICT by smallholder sheep farmers.
4. To investigate the willingness of sheep farmers to adopt the record-keeping application.

1.6 Ethical considerations

This research will involve engaging professionals in the sheep production industry in South Africa on farms and other organizations. Ethical concerns will be handled, as the researcher will be involved in the process. Interviews will involve adults with their permission before the interview occurs, and any anonymity appeal will be respected. The study will also comply with the guidelines of the University on ethics regarding scientific research. The project was part of a broader one and used the ethical clearance number 9293.

1.7 Thesis outline

- Chapter 1 gives brief background information on the study, justifies the reason for conducting the research study, and outlines its objectives.
- Chapter 2 outlines a review of literature relevant to the study.
- Chapter 3 consists of the research methodology of the research.
- Chapter 4 The results and discussions of the thesis are presented.
- Chapter 5 summarises the findings from the study as well as recommendations.
- All the references cited in this study are found in the reference list at the end of chapter 5.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The livestock sector is an engine of global economic growth and a source for inclusive development and Sustainable Development Goals (SDG) (FAO, 2018). The SDGs are focused on the Millennium Development Goals (2000-2015) with an even greater focus on ending poverty and hunger. They aim to address the root causes of poverty and global growth in a sustainable way (SDGs #1, 2, 15) (FAO, 2018c). SDG1 adopts a multi-dimensional approach to eradicating poverty with objectives of combating extreme poverty, fostering sustainable economic development, equitable ownership of economic capital and rights of the land, and building resilience to withstand economic, social and environmental shock at national and regional level (FAO, 2018a). SDG 2 has an overall framework approach to hunger, based on food security achievement and nutrition enhancement and sustainable agriculture promotion (Bruinsma, 2017; FAO, 2018c, 2018b). Livestock and animal foods efficiently provide digestible protein and essential nutrients, contributing significantly to ending malnutrition and improving health and food safety. More than 18% of the world's population is engaged in animal husbandry or animal-based food processing and marketing (Shekhawat, 2016). Lastly, SDG 15 aims at enhancing the provision of ecosystem services of any environment with explicit goals on wildlife and genetic resources protection, land regeneration, preventing deforestation and fighting desertification. Livestock is the fastest growing agricultural sub-sector today, making up five of the world's six highest value commodities and 40% agricultural Gross Domestic Product (GDP) in developing nations (Bruinsma, 2017).

Sustainable livestock farming is vital to guarantee that resources are continuously available to future generations (Molotsi et al., 2017). Food and Agriculture Organisation (2018) emphasizes that, without attention to the livestock sector, the eradication of hunger and improved food safety is highly impossible. An even more significant challenge would be increased food security and elimination of hunger without livestock, as most households rely on the livestock sector for subsistence farming, income, insurance and food (FAO, 2018a). Livestock production is an important agricultural stronghold that contributes immensely to improving the rural livelihoods in South Africa and contributes to its GDP forestry and fisheries (Cloete & Olivier, 2012b). Cattle or sheep have a vital role in supplying food by strengthening the household economy through draught power, organic fertilizer and fuel. Livestock plays various roles on farms and fulfils the different goals the resource-poor farmers want to achieve (Mapiye *et al.*, 2009). Access to food continued good health, and labour to pursue activities are some of the importance of livestock for

farmers. Livestock production aids in creating social capital, reinforcing the cultural diversity and traditions of some ethnic groups and communities (Mapiliyao, 2010) and contributing to resources and services for the maintenance and development of livelihoods (Lubabalo & Mupangwa, 2009). It also increases financial resources, provides investment mechanisms, and acts as liquid assets or credit collateral to protect livelihood goals (FAO, 2002; Otte *et al.*, 2005; FAO, 2012).

Almost two-thirds of the 5 billion hectares categorized as 'farmland' in the world are unsuitable for crop production and can only be used for livestock grazing. In addition to using grasslands to sustain human livelihoods, livestock often transforms vast quantities of plant materials that humans cannot consume (e.g., straws, stoves, oilseed cakes, among others) into valuable food (FAO, 2012). Livestock production is prevalent, with rangelands occupying up to 25 per cent of the earth's land area. Livestock occupies about 70% of the field, while 33% of the cropland is used to produce fodder (FAO, 2018c). Also, livestock production supplied 25% of protein and 18% of calories consumed globally in 2016, both of which are necessary for nutrition security (Mottet *et al.*, 2017). Livestock manure is a source of organic fertilization, turning waste inputs into high-value food for more than 50% of most of the world's farmlands (Bruinsma, 2017; FAO, 2018c). Manure plays a vital role in replenishing organic soil, which is necessary to preserve soil health and quality and sustain crop productivity (FAO, 2018b) and be used as an income source (Almeida, 2011).

Sheep produce four main products: meat, wool/hair, milk, and skins. Meat is the main product in many parts of the world, particularly the temperate regions, and the value of meat production is increasing worldwide (Morris, 2009). Based on the latest information from the National Department of Agriculture, total sheep numbers are in the order of 22.18 million in 2019, which is 1,4% lower than in 2018 and 9,8% lower than ten years ago (Cornelius, 2020). The high occurrence of organized theft of sheep in South Africa and the present drought in the Northern Cape and parts of the Free State and Eastern Province is expected to have a negative effect on sheep numbers in sheep numbers over the next 12 months in South Africa, which may result in a further decline in the national herd. A significant characteristic of sheep is, thriving and production on land unfavourable to other farming forms. Various breeds of single or dual-purpose sheep types have been produced with high production levels under suitable environments and management systems. Sheep can also forage and live in areas where cattle will have a low output (Morris, 2009; Almeida, 2011). The ewes are also preserved, primarily for wool and meat in South Africa, for milk products in the Mediterranean and East European countries in particular (Morris, 2009). The actual world sheep meat consumption is around 2.5kg per person annually, out of total meat consumption of 41.6 kg per person, which is comparatively low (FAO, 2008).

2.2 Characteristics of sheep farming in South Africa

According to the Food and Agriculture Organization of the United Nations (Gilbert *et al.*, 2018), the world's largest sheep population was estimated at over 1.2 billion, with South Africa contributing only 28.8 million of the total flock (Directorate Statistics and Economic Research, 2013). Sheep breeding is practised nationwide but focused mainly in the country's more temperate parts: Northern Cape, Eastern Cape, Western Cape, Free State and Mpumalanga. There are nearly 8 000 commercial sheep farms across the country and approximately 5 800 communal farms (Cloete & Olivier, 2012a). The industry is dominated by the commercial sheep sector, which supplies local meat products and export wool products. However, sheep farming allows sustainable production in extensive pastoral areas where no alternative farming ventures, such as the vast, extensive Karoo regions in the central part of South Africa, can be practised. (AGIS, 2007e; Conradie *et al.*, 2013; Department of Agriculture, 2011; Diepen, Mclean & Frost, in press). Sheep production also complements crop farming, with sheep using crop residues and by-products from preferred ley-farming systems in South Africa (Cloete & Olivier, 2012a). During years of crop failure due to drought or disease and periods of unstable grain prices, farmers rely on sheep farming to provide for their families and employees with a livelihood. Many rural communities depend for their existence on sheep and for maintaining a viable local society. Without the income from sheep goods, many rural towns will cease to exist, as the industry often supports all stakeholders in the related slaughter, wool processing, and tanning industries.

According to Cloete & Olivier (2012b) and Hoffman *et al.*, (2003), South African sheep farmers face ever-increasing input costs resulting in lower profit margins. Local farmers need to run their businesses most productively to survive economically. The national flock consists of several breeds bred for either wool or meat or dual-purpose breeds bred for the production of both commodities. Merino is the main wool-producing sheep in South Africa, with Dohne Merino and SA Mutton Merino (SAMM) being considered dual-purpose breeds. The main sheep breeds bred for meat production are the Dorper and Dorper breeds (Cloete *et al.*, 2014a). Meatmaster is a relatively novel composite breed, well suited and selected for good fertility and growth characteristics, and is increasingly popular (Peters *et al.*, 2010). Hair sheep breeds (Dorper and Meatmaster) are considered early maturing breeds, while Merino is considered a late-maturing breed. The dual-purpose (Dohne Merino and SAMM) and the Dorper breeds are medium maturing breeds relative to the previous breeds. Cloete & Olivier (2012b) have shown that Dorper lambs are early maturing relative to SAMM lambs. Indigenous sheep breeds in South Africa include Damara, Pedi, Van Rooy, Blackhead Speckled Persian, Redhead Speckled Persian, Blinkhaar Ronderib Afrikaner, Zulu, Namaqua Afrikaner, Karakul, Swazi and Dorper. Fat-tailed and fat-rump sheep have been kept in Southern Africa for decades. (Cloete & Olivier, 2012a; Cloete *et al.*, 2014b). The best-known breed, the

Damara, was associated with nomadic herdsman on the western seaboard. The Blinkhaar Ronderib Afrikaner breed is a typical fat-tailed sheep, well-adapted to arid environments (Department of Agriculture, 2011). It originated from selective breeding to develop sheep with shiny coats suitable for making skin blanket. Rams from this breed are known to perform exceptionally well as teaser rams (Cloete & Olivier, 2012b).

Van Rooy sheep are found throughout South Africa, although numbers are limited in some regions. The South African fat-rump black-headed Persian population was founded from North African sheep introduced after a shipwreck in 1869 (Cloete & Olivier, 2012b). The breed adapted so well to South African conditions that it was used as a dam line in the formation of the Dorper breed, where it was used to ensure that the resultant composite would be hardy under arid conditions. The Dorper was established with the purpose of a semi-arid breed to have Dorset Horn and Blackhead Persian (Milne, 2000). The Namaqua Afrikaner is a low mature, unimproved, fat tail breed that survives harsh environmental conditions (Qwabe *et al.*, 2012). These breeds vary in their development and maturity characteristics and are more suited for communal sheep farming systems associated with high mortality frequency, low reproductive rate, low weaning percentage, and low turnover (Morbidini *et al.*, 2001; Doyle, 2018). Housing, sanitation, and insufficient feeding and nutrition are the major problems of low livestock productivity in communal areas. However, lamb mortality, poor marketing management, limited feed availability, shortage of extension delivery staff and lack of farming records also contribute to low productivity in communal sheep farming systems (Kusina *et al.*, 2001; Mapiliyao, 2010).

Current sheep production systems can be classified into two main classes in Southern Africa, namely extensive and intensive systems. An intensive sheep farming system typically involves a system available in or combined with a feeding system or production system from pastures (Diepen *et al.*, 2007; Mapiliyao, 2010; Mthi, 2017). The intensive production systems are aimed at increasing the production per unit per year and are distinguished by the use of cultivated pastures in order to increase the stocking rate, as well as the quantity and quality of animal feed (Diepen *et al.*, 2007; Van Der Merwe *et al.*, 2020; Terblanche, 2013). Intensive sheep production systems aim to maximize the output per unit or hectare of production. Extensive management systems for sheep production, ranging from lowland farming systems where relatively small flocks graze fenced enclosures to rangeland management systems where large flocks live on unclosed pastures, are the most common in all sheep-producing countries (Terblanche, 2013). Local requirements are followed by flock size, sheep's ratio to shepherds, and basic management activities (Kilgour *et al.*, 2008). In South Africa, under extensive conditions, the sheep production system aims to produce at least one marketable lamb per ewe per year (Terblanche, 2013). The lambing season of extensive production systems is determined primarily by the natural feed growing season in a specific region.

Additional feed is provided to animals as supplementation in extensive systems when pastures or stubbles are deficient in energy and protein to meet the nutritional requirements of various sheep groups. In different locations, various diseases occur, and a trained veterinarian must develop a vaccination program appropriate to the producer's location. The ewe will have 2.5 possibilities (42 days) to conceive, and the current standard practice is to cull all ewes that have not conceived after a 60-day breeding period. (Terblanche, 2013; Arandas *et al.*, 2020).

Depending on the breed, lambs are weaned in comprehensive systems at approximately 120 to 150 days of age. Current output from vast production systems is declining, and sheep production will likely switch towards more intensive production systems, benefiting from higher production prices (Terblanche, 2013). The withdrawal is because livestock farmers in South Africa and Namibia have diversified into other vast livestock production systems such as game (Van Wyk, 2011), health consciousness of consumers, stock theft and predation (Terblanche, 2013). Another sheep production system in South Africa is the Karoo lamb, a low-input and extensive production system (Kirsten *et al.*, 2008). Karoo farms usually have a low grazing range, with the norm estimated at 35 ha per large stock unit in most areas (Erasmus, 2017).

2.3 Karoo lamb

Lamb meat originating from the Karoo region is widely known in South Africa as Karoo lamb. The Karoo covers 30% of the total area of South Africa, with the most prominent part falling within the province of the Northern Cape (Olivier & Roux, 2007; Du Plessis & Du Rand, 2012; Van der Merwe *et al.*, 2018). The Karoo essentially consists of two biomes, the Succulent Karoo and the Nama-Karoo (Henschel, Hoffman and Walker, 2018; Timm Hoffman *et al.*, 2018). Many of these species are vital for conservation, so the biome is considered a globally significant biodiversity hotspot. The biome covers approximately 427 000km² and is geologically, meteorologically and botanically diverse. (Cowling, 1986) (Fig 1.).

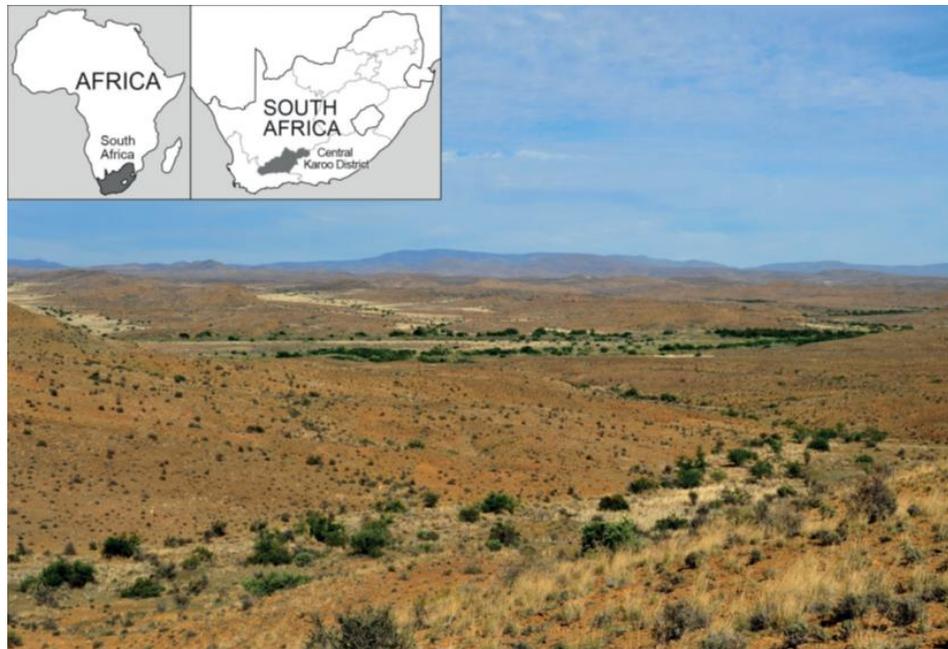


Fig 1: Photograph of a typical livestock farm landscape in the Central Karoo District Municipality. Source: Drouilly *et al.*, (2018)

The meat is primarily known for its excellent quality and distinctive taste. Karoo lamb is a product with regional properties, depending, among other things, on the natural environment of the area of origin (Du Plessis & Du Rand, 2012). It is one of the first red meat products to be regarded as a PGI (Protected Geographical Indication - Where there must be a geographical relation in at least one of the production stages) (Erasmus, 2017). The Karoo lamb has been part of the African culture for centuries and represents the Afrikaner and Cape cuisine. It is assumed that the meat's typical sensory characteristics can be due to the free-range conditions in which the animals roam. Merino, Dorper, Dohne Merino are the three main sheep breeds used to produce Karoo lamb. (Cloete & Olivier, 2010). Karoo lamb is typically sold directly from the veld with no extra feed given to the sheep. Most Karoo lamb farmers use more than 1 000 ha with over 200 ewes (Kirsten *et al.*, 2008). If the ram and ewe lambs achieve 30-40 kg of the target body weight, they are transported to registered abattoirs and sold. Ram lambs are slaughtered before puberty, but they are not castrated. The meat is ultimately transported from abattoirs to wholesalers, retailers and butchers. As food markets have expanded globally, consumers are increasingly concerned about their food origin and are more passionate about high-quality food with a significant regional identity (Erasmus, 2017). The relation between food and soil has been eroded over time by natural food products based on soil and regional or geographical origin.

Karoo lamb is classified as sheep meat bearing the Karoo certification label under the specifications of Karoo Meat of Origin's certification scheme. Sheep meat is processed and slaughtered in the Karoo region,

regardless of breed. Only the sheep come from [i.e. born in the Karoo or born outside the Karoo, but remain in] the Karoo for a continuous span of at least six months, immediately before slaughter and free from disease. Karoo sheep is produced from free-range grazing with access to clean water in native veld vegetation (Erasmus, 2017). The certification mark guarantees that the authentic Karoo lamb originates from animals raised on the natural veld, with at least two of the six fragrant native shrubs scientifically proven to infuse a unique herbal taste in the meat. As in Karoo lamb, regional image influences establish a unique identity for a commodity and specific product qualities and generate additional value (Erasmus, 2017). However, as required by the Animal Health Act of 2002, minor doses for the treatment or prevention of sheep diseases are given (DAFF, 2002).

2.4 Organic sheep farming

Organic sheep farming refers to the breeding and production of sheep free from genetically modified organisms (GMOs). Hormones, pesticides, other banned growth promoters, plastic roughage pellets, manure refills, mammalian or poultry animal by-products, and urea are not used in the organically manufactured feed organic farms. Organically managed pastures or field units must be accredited. If organically produced, synthetic vitamin and mineral supplements can be used when not available and nutritional deficiency is known. Sustainable sheep production is pasture-based and requires little or no supplemental feed. Producing forage on-site and without the use of energy-intensive inputs generally lowers embodied energy in sheep feed. Additives such as hormones, pesticides, herbicides and antibiotics used in intensive agricultural production systems and the use of hormones have led to consumer concern about food safety, animal welfare and the increase in the market for organic or free-range food (Rahmann *et al.*, 2007; Hale *et al.*, 2010). Organic farming seeks to develop and preserve the interdependence of land, plant and animal soils and to create a sustainable agroecological system based on local resources (Thompson & Nardone, 1999).

Consumers have demonstrated a demand for more animal-friendly food (for example, free-range). The consumer also uses animal welfare to indicate other key product features, such as food safety and quality (Harper & Henson, 1999). Research has shown that, because of health reasons, consumers purchase organic products, better taste, and free from BSE and other food additives and also buy products for ethical reasons. Consumers concerned about animal welfare problems are also prepared to pay for better animal welfare standards (Bennet, 1996). However, organic farming is not the only form of production that fixes sustainable livestock production problems. The production method is primarily used for a specific premium market that needs unique management skills. (Nardone *et al.*, 2004). Reasons contributing to this sector's development include its high capability for meeting increased consumer demand for environmentally

friendly products associated with animal welfare, such as Karoo lamb (Rahmann *et al.*, 2016; Pérez *et al.*, 2017) and this is possible if the product can be traced back to its production site.

2.5 Traceability

Organic agriculture, or the certification mark for Karoo lamb, aims to establish a sustainable production system and a range of high-quality products focusing on the conservation of the environment, biodiversity, and high standards of animal protection (Tung, 2016). This is made possible if the system that enables traceability of products is up to standard. Meat traceability is described as retaining credible animal identification custody through various food chain steps from farm to retailer. Smith *et al.*, (2005) refer to traceability as the ability to distinguish farm animals (livestock and poultry) and their products; (especially their meat). Depending on their sources, it is as far back as possible in the production sequence to determine ownership, recognize parentage, enhance palatability, ensure food protection and ensure compliance (e.g., for source-verification, process-verification, production practice-verification, branded-beef program constraints, beef export verification, authenticity management). Traceability can be a critical tool to determine the authenticity of food goods and verify that suppliers' claims are accurate (Van Rijswijk *et al.*, 2008). It helps consumers to access reliable, targeted information. The desired characteristics are presented at the production level and cannot be added during manufacturing to differentiate a product of animal origin. Therefore, Karoo certified lamb customers could be confused as to whether the true source of the lamb and the prestige and logo of the product are sold in outlets.

Customers face several competing products in their purchase choice. Purchase decisions are usually focused on several features, such as price, functionality (such as tracking the supply chain of meat), physical appearance, guarantee, brand name and designation of origin. Increased consumer understanding of food safety issues adds to the need for more information on the vertical food supply chain and the origin and care of food manufactured and consumed worldwide. (Smith *et al.*, 2005). Although food traceability systems guarantee nothing but the ability to track the product across the food chain, they are essential to ensure the product's safety and implement quality standards. (Ntokwane, 2016).

Sheep farmers need to comply with the Karoo and organic production laws, evident at all stages, to be marketed with a price premium as an organic or Karoo. Most certification plans use a mark as a guide to help customers identify goods that meet certification requirements. Consumers cannot be sure of a label's authenticity when buying food at retail stores without a regulatory structure governing organic and Karoo meat selling and processing (Tung, 2016). Traceability can be considered a buying and trust criterion in the Karoo certified lamb, primarily as it provides information about the origin, producer and ingredient. Product

traceability is accomplished when farmers keep records, which is ideal to please customers because it is hard to run a farm business as their parents did 30 years ago, faced with the recent global economic crisis and the fast speeds of the agricultural industry hence there is need to use proper records (Du Plessis & Du Rand, 2012; Erasmus, 2017). For smallholder sheep farmers, marketing and selling meat as Karoo lamb would mean more profits and contribute to maximizing productivity, which is made possible by keeping proper records for traceability purposes.

2.6 Record-Keeping

Using farm records is one potential solution to improving smallholder farming and also to assist with traceability. (Tham-Agyekum *et al.*, 2010; Johnny Dudafa, 2013). Farmers might fail to make it very far in today's market without farm records because a farmer who keeps an appropriate collection of records will generally manage issues better than one who does not. Farmers also regard record keeping as a difficult job, considering the importance of farm records to the growth of a farm business (Poggio, 2006), and thus the decisions they make are driven by uncertain estimates and guesses based on their past farming experience (Johl & Kapur, 2001). Farm record keeping requires gathering an account of the daily activities of a farmer on the farm. No widely accepted concept of farm records is available. However, as Tham-Agyekum *et al* (2010) highlighted, farm record keeping is defined by a farmer's keeping accurate records of his estate's daily activities, profits, and expenditures. He added that record-keeping refers to a research organization's data collection operation that includes keeping records of a community of farmers with some guidance and assistance from a research organization. Muhammad *et al* (2004) noted that productive farmers' key practice is farm record keeping and vice versa.

Detailed written farm records are instrumental in proper planning but also in identity preservation required for full traceability. Tham-Agyekum *et al* (2010) reported that a farmer who has a well-kept farm record is in a more advantageous position than one who has no farm records of borrowing required funds. There are numerous types of farm records, but they are categorized under four general types (Omoruyi, 1999; Poggio, 2006). These are resource inventories, production records, financial records, and supplementary records. Resource inventories include farm assets and liabilities, while production records include mortality, breeding, bird performance, feed data, laying and labour. Financial reports provide revenue from sales and expenditure on meat, vaccines, labour and farm machinery maintenance (Poggio, 2006). Additional records are the survey map, the farm layout (map) and the farm legal documents. A working record-keeping system representing the group's breeding aim is of fundamental importance in the dynamics of the sheep flock. Farm ventures in South Africa have shown that farmers are willing to participate in the record-keeping

scheme if there is no counter-productive interference and information and expertise is made available to livestock farmers.

Another niche market for smallholders sheep farmers is Karoo-certified lamb, as long as it is part of the geographically demarcated region. Certification, especially for smallholder farmers willing to move from subsistence to commercial/emerging agriculture practices, should be possible. Marketing their goods on the market would allow farmers to increase prices and supply niche markets with their products. Given their numbers, farmers can theoretically exploit stable long-term contracts by creating cooperatives, pooling inventories and ensuring sustainable long-term distribution for their customers. This setup would make it easier for funders to support since it will not be offered to farmers. In the premises of the cooperative, weighting facilities and loading systems can be developed, which facilitate easy marketing by farmers (Molotsi *et al*, 2020), and this is exceptionally made possible if farmers have records in place. The primary function of cooperatives in the sheep sector is slaughtering and marketing. The risk of market failure is more seen in isolated regions, where the distance to the market is significant and where effective trade is hindered because of the lack of competition of potential buyers. Cooperative market systems are used to set up the side activities and improve the cooperative's financial results. If there are proper record-keeping measures for traceability purposes, it brings about better opportunities for financial improvement for smallholder sheep farmers (Theodorakopoulou, I, Iliopoulos, 2012).

The importance and significance of the various types of records would vary with the different sheep processing systems. The purpose of keeping records and accounts is to increase efficiency. Without documents, it is impossible to address production and management practices that affect overall productivity. With documents, decision-making tools for problem-solving, determining management goals and establishing development and marketing targets are in place. (Scott, 2011). Hence, the traceability systems create a means to provide consumers with information about a meat product's production process and further connects the consumer with the sheep farmers. These systems improve the reputation of the whole supply chain and the meat product supplied to the benefit of both the consumers and the farmers (Kirsten, Jordaan & Van Der Merwe, 2013).

2.7 Attitude of farmers towards record-keeping

It is likely that an even more significant number of farmers have some interest in keeping proper records of production but have insufficient resources (Mapiye, 2017). In a survey conducted by Chiwawa (2019) on whether farmers were willing to use a record-keeping database, most sheep producers surveyed in the Western Cape province answered positively. Apart from municipal differences, positive responses to this

question indicated the usefulness of keeping records and age (younger farmers expressed more agreement than the elderly). Historically, sheep farmers have identified problems with adopting farm record-keeping systems. Farmers mention the professional challenge in getting used to new systems, and in other studies that have been done, farmers saw the decision to shift recording means as farm business-related rather than associated with ideology and a lifestyle change (Mapiye, 2017; Chiwawa, 2019; Molotsi *et al.*, 2019b). No model can be effective if the end-users do not understand the actual value of the services. Many of these ventures have issues with consumer acceptance because they cannot persuade potential customers to try these services. (FAO, 2013). Providers should understand precisely what knowledge is essential to farmers and provide it in ways that make it easy to absorb and act, avoiding "data dumps." However, it is important to demonstrate how the application for record-keeping works for farmers before they believe it is being imposed on them.

2.8 Information and Computer Technologies (ICT)

Agriculture is a significant component of Africa's economic life, with livestock being an essential part. Through increased food production, agricultural resources, fertilizer, fuel, transportation and nutritional protection and income, livestock farming contributes immensely to urban and rural communities. Agriculture, like most industries, is an information-intensive industry, and ICTs play a key role in facilitating the exchange of information (Todaro, 2000). From the perspective of the growth, flow, and management of information and ideas, the information could be visualized in the livestock farming system's various links, namely input/procurement, processing, marketing, sales, and health management issues. ICT may allow farmers in Africa to access current information effectively and also provide buyers and consumers with information through innovative pathways, such as the incorporation of farmers' online communities, advertising on local farmers markets, and accessing social network sites such as Facebook to promote the community interest in farmers' activities (Gwaka, 2017; Dhehibi *et al.*, 2020).

Most of the local livestock data in South Africa is fed into the consolidated Integrated Registry and Genetic Information System (INTERGIS) operated by the National Recording and Improvement Schemes of the Animal Improvement Institute. The system allows for creating national productivity benchmarks for livestock to compare livestock's genetic potential and then provide a reliable reference source for policymakers and farmers (Van der Westhuize, 2003). In Botswana, the Livestock Identification Track Bank System (LITS) also exists to encourage livestock management practices. In every aspect of today's human life, including agriculture, ICTs play a vital role. Agriculture's leading players are farmers, and their technical capacity determines the role of ICT generally in agriculture. The use of ICT by farmers is

increasing worldwide. ICT provides the ability to improve production, productivity, competitiveness and development in various aspects of the agricultural sector by increasing access and knowledge exchange. It would be expected that farmers engaged in large-scale commercial agriculture would use cameras, computer equipment, digital imagery, internet, Wi-Fi access, SMS services, mobile and digital media and DVD Internet access, for example. Small-scale farmers use different other types of ICT, for example, cell phones, computers and the internet (Nwagwu & Soremi, 2015; Gwaka, 2017; Brand & Galdava, 2019).

Using ICT will also allow farmers to use their savings in various ways, with many investing their extra income back into their companies or paying for their children to go to school (Jama *et al.*, 2004). The deployment of ICT in livestock as done in Nigerian communities is expected to be fragmented with differences in terms of the degree and efficiency of telecommunication services, the capability and demographic characteristics of individuals and the size of enterprises in which those individuals are associated (Nwagwu and Soremi, 2015). Farmers who are highly trained or engaged in large-scale farming, for example, will more likely deploy ICT more than others. Also, mobile phones and other ICTs can effectively be used by farmers to alert customers of availability or discuss prices and negotiate prices. Many farmers live far away and interact with farmers often to understand their farm conditions. (Gwaka, 2017; Tijjani *et al.*, 2017). On educational aspects, farmers can learn how to manage farms, feed or manage diseases and others by browsing the internet or linking with their vets, fellow farmers and others. As in all health conditions, animal health problems can arise at any time, and farmers may need to contact their health care providers to either visit farms or provide advice about what can be done to cope with the situation. Farmers can visit the internet, use email or mobile phones or any other instant messaging device to find out what to do. (Chiwawa, 2019; Dhehibi *et al.*, 2020; Tijjani *et al.*, 2017).

Similar studies are in place, but experiences with farmworkers and agro-enterprises and literature sources (Agwu & Uche-Mba, 2010) show that costs related to technology, lack of training, lack of ICT expertise, lack of technical infrastructure and reluctance to use new technologies could influence the utilization of ICTs by farmers in Africa. (Inegbenebor and Ogunrin, 2010; Nwagwu and Soremi, 2015). ICT can typically contribute to agriculture in three ways: data and knowledge processing, marketing, learning and capacity building, agricultural services. Adequate knowledge to manage livestock farming is needed at the individual, community and state levels. Policies and plans must be developed; activities to ensure that initiatives and programs reach their intended targets have also to be controlled and evaluated (NEPAD, 2006) and for the benefit of various stakeholders.

In a previous study by Chiwawa (2019), a record-keeping software for sheep farmers was developed to be innovative and not reshuffle traditional systems. The purpose of the application is to add value to native sheep breeds by creating new knowledge and providing scientific evidence on particular biological

characteristics. Better knowledge of the problems that disrupt smallholder sheep farming development is needed to achieve better production and productivity. The study results indicated that sheep farmers in the Western Cape faced various challenges (Chiwawa, 2019), including limited internet access, poor security and Eskom's inadequate power supply. The farmers helped in the design and creation of a web application for record-keeping. The farmers indicated the design and development features they required, and they also highlighted barriers to implementing and using resources such as an online monitoring system. The previous study results showed that smallholder sheep farmers face other problems, such as environmental and socio-economic challenges, in the Western Cape. Drought, lack of food, water scarcity, pests, diseases and predation are among the problems. However, the purpose of this study will focus more on the adoption and use of the web-based record-keeping application developed after the previous study, as recommended that there is a need for the application to be introduced to farmers (Chiwawa, 2019).

Conclusion

Challenges and constraints specific to using ICT in the sheep farming sector need to be identified and characterized before new technologies are implemented (Dudafa, 2013). They are still moving towards understanding the constraints in the evolving commercial farmer context, as digital literacy and the availability of ICTs in South Africa are growing (Gillwald *et al.*, 2012), sheep farmers could use the record-keeping application to produce better and as means of communication on the stock on their farms. It will also be helpful to extension workers and others in the sheep industry. ICTs have demonstrated the ability to change agricultural extension systems and distribution, including farmers' experiences. Although information transfer strategies have been motivated to improve recent technology adoption by farmers, the adoption rate of ICT remains significantly low (Dhehibi *et al.*, 2020) and consequently affects farm economic sustainability and performance. The adoption and use of record-keeping applications are vital to facilitate effective recording systems in sheep farming that will aid in the traceability of the Karoo and organic farmers' products.

CHAPTER 3

METHODOLOGY

The research adopted a mixed-method analysis methodology. Wisdom & Creswell (2013) described research into mixed methods as an approach that develops a methodological integration or combination within a single research analysis of qualitative and quantitative data. The sequential exploratory cross-cutting analysis method in this study is a technique that is intended primarily for investigating the problems and benefits concerning the tracking and preservation of ICTs for data reporting by smallholder sheep owners, information and access record-keeping by both. The mixed-method analysis methodology enables researchers to work from views that encourage them to investigate, discover and analyze the issues compatible with their values, viewpoints and most relevant to the academic community (Teddlie & Tashakkori, 2009).

3.1 Materials and Methods

3.1.1 Study location description

The analysis combined two districts in the Western Cape, Eden and the Central Karoo (Beaufort West), shown in Fig 3.1 below. These areas were selected because they are located in arid environments and because in these areas, sheep are generally produced extensively (Molotsi, 2017). Eden in the Klein Karoo is a unique South African area as four of the seven biomes fall within its boundaries. Two of the twenty-five known biodiversity hotspots globally are the Fynbos and Succulent Karoo biomes, whereas Central Karoo is characterized by the Nama-Karoo biome (Acocks, 1988; Henschel, *et al.*, 2018; Walker *et al.*, 2018). The succulent Karoo is a winter rainfall area with succulent plants. The sea level ranges between 1500 and 3500m, with average annual rainfall. Grass bushes are the dominant vegetation of Nama Karoo and range from 1000 to 1400m above sea level. The Nama-Karoo biome is a mixture of steppe type vegetation, annual and permanent grasses, covering most central and western areas of South Africa. The biome is related to moderate precipitation regions and suitable for the commercial production of sheep and goat. Farmers located 50km radius from Beaufort West and Eden participated in the research.

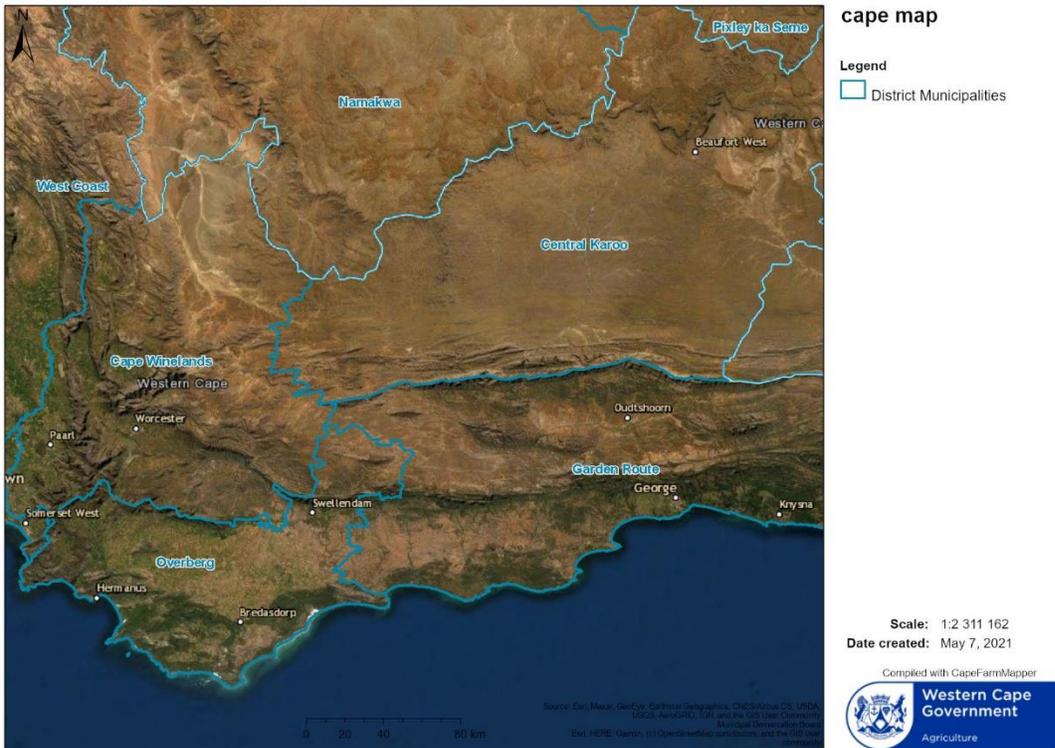


Fig 3. 1 Map showing the site of study in the Western Cape Province in South Africa. (Garden Route and Beaufort West). Source (“Cape Farm Mapper 2.3.4”, 2021)

3.1.2 Pilot study

As Oppenheim (2003) suggested, a pilot study was conducted in August 2020 with three sheep farmers in the Eden area to test the questionnaire to estimate the time required to complete it. On average, the time needed to complete each questionnaire was 45 minutes. Questions that were unclear to the respondents were defined and updated and then repeated for the final interviews.

3.1.3 Sampling

A presentation was done at Outeniqua Research Farm, two weeks before fieldwork to the Western Cape Government, Department of Agriculture extension workers. Fourteen extension workers were present, and their role was to understand the survey's requirements and provide assistance and details of farmers to participate in the research survey. The presentation explained how the research would be done, its purpose and importance, and the time to complete the questionnaire. The researcher assured the extension officers about the questionnaire's confidentiality and the respondent would not be disclosed under any circumstance. Both telephonic and physical interviews were done with the farmers who participated in the survey. The contact details of these farmers were provided by the extension officers working on projects with the

farmers. Each extension officer would select farmers working on projects with them and those comfortable participating in the interviews.

3.1.4 Research sampling method and population

The selection of participants or farmers for the research was based on a previous study conducted in the same region by Chiwawa (2019) and Molotsi (2017). Initially, participants were chosen using a system of purposeful sampling. According to Plastow (2016), a purposeful sampling method is a sampling method that allows the researcher to select the participants based on the characteristics of the population and the study's objective. However, the extension officials helped with the specifics of the two districts because of the lock-down restrictions and regulations. This list included farmers involved in public projects or receiving government funding. Farmers who were willing to participate in the research were also included. Fieldwork interviews were conducted with 53 sheep farmers, 25 in the Eden and 28 in the Central Karoo. This approach was considered very necessary after preliminary observations hinted of the difficulty of carrying out interviews due to the key respondents' absence in the farms or their schedules' tightness.

Telephone calls to ten of the respondents were made between 08h00 and 17h00 during weekdays because this appeared to be the most appropriate for them since they could not participate in physical interviews. Farmers in the list provided were contacted a week in advance to confirm appointments. The fieldwork was performed based on the availability of extension staff, and farmers who lived next to each other had to be found to schedule appointments on the same day. A maximum of three interviews could be conducted in one day, depending on the respondents' availability, the distance between the farms, the weather and the road conditions, but on average, two interviews could be completed in one day. Data were compiled using semi-structured questionnaires in discussions and surveys with sheep farmers. Discussions with farmers led to quality assessment of strengths, constraints, risks and software applications and other sheep farmers' challenges, and this was recorded in the questionnaire during interviews.

3.3 Research questionnaire design

The template used in creating the research survey questionnaire (Appendix 1) for this research was a questionnaire used by Swarnkar & Singh (2010) and Tijjani *et al.*, (2017) to assess which factors inhibited farmers' acceptance of the research approach. The questions were classified under the following categories:

- (i) Demography of farmers
- (ii) Farm information

- (iii) Production information
- (iv) Record-keeping measures
- (v) Perception of farmers towards adoption

A questionnaire was given for open-ended and closed-ended questions (Appendix 1). Some closed questions were multiple-answer questions where respondents could make more than one choice. The open-ended questions were added to the questionnaire to encourage spontaneous and free answers (Oppenheim, 2003). Consequently, the respondents were not limited to the questionnaire designer's choices when answering those questions. The questionnaire was drawn up in English and Afrikaans because most farmers use most of the Afrikaans language in the districts of Eden and Beaufort West. The concept questionnaire was circulated to the supervisors for feedback and recommendations, and it was reproduced for the pilot study. All respondents were interviewed by appointment on their farms. To confirm whether they understood the process, farmers were asked to motivate their responses.

3.3 Data collection

In addition to demographic variables, level of familiarity was assessed by listing Information and Computer Technologies known by the farmers, and respondents were requested to apply their response on a low, medium- and advanced 3-level scale. The technologies the farmers have used were valuable to them, and examples of the ICT they used were given. The various issues included in the survey questionnaire were the challenges and benefits of manual record-keeping, access and reliability, information needs, and the farmers' perceptions after sampling the software application. The second part of the interviews involved a demonstration of the record-keeping application (Figure 3.2), showing farmers the record-keeping application (Sheep breeding management) and its functions. Dialogues using a SWOT (Strength, Weaknesses, Opportunities and Threats) method to comprehend the farmer's opinions and to know the challenges and benefits associated with the record-keeping application in sheep farming storage of data by sheep farmers were done afterwards with the respondents also giving responses on how they view the application and were recorded on a five-point Likert scale (Semie *et al.*, 2009).

Sheep Breeding Management



Farms

Farm	Farmer
No farms available	
farm name	<input type="text"/>
farm size (in hectares)	<input type="text"/>
latitude	<input type="text" value="0"/>
longitude	<input type="text" value="0"/>
<input type="button" value="Add Farm"/>	

Farms

Farm	Farmer	
Bergsig	no farmer set	<input type="button" value="view"/>
La Gratia	no farmer set	<input type="button" value="view"/>
AtisaTiro	no farmer set	<input type="button" value="view"/>
	no farmer set	<input type="button" value="view"/>
Molotsi	no farmer set	<input type="button" value="view"/>
	no farmer set	<input type="button" value="view"/>
Annelin	no farmer set	<input type="button" value="view"/>

farm name

farm size (in hectares)

latitude

longitude

< Farms

View Farm

Farm Information

Farm Name Annelin
 Latitude -34.14664382256434
 Longitude 22.89383874727117
 Farm Size (hectares) 320

Farmer Information

No farmer assigned

farmer name

farmer gender

farmer birth date

Farm Rainfall Information

Date	Amount
No rainfall added	

< Farms < Farmer

View Breed

Breed Information

Breed Name Dorper

Breed Sheep Information

Animal ID	Gender	DoB	
103	Ewe	2020-09-29	<input type="button" value="view"/>

animal ID

gender

date of birth

birth weight

weaning weight

View Sheep

Animal ID 103
 M/F Female
 Date of Birth 2020-09-29
 Birth Weight 3.5
 Weaning Weight 28
 Status dry

Sheep Mating Information

Date	Scrotal Circumference	BCS at Mating	BCS at Lambing	Mating Weight
No matings added				

mating date

ram ID

scrotal circumference

BCS at mating

BCS at lambing

mating weight

Adding Lambs

Queue lambs here and add them by clicking on a lamb button in the mating

Fig 3. 2 The user interface of the Sheep Breeding Management record-keeping application

For those not literate in English, the researcher administered the questionnaire by reading out each question, with the help of three translators and extension workers interpreting what had been read in Afrikaans and helping the respondent tick the response appropriately. The responses of those who were unable to speak and write in English were translated to English. Since participants were farmers and would need ample time to carry out their daily tasks, data collection was spread over five weeks. Apart from data collected using the questionnaire, several visits to the farms granted the researcher a first-hand interaction opportunity to observe and assess the farmers' ICT environment. COVID-19 protocols were adhered to, wearing masks, sanitizing hands, and maintaining social distancing while interviewing farmers. Data was obtained between the periods of August to November 2020, during the lockdown level 2.

3.4 Statistical Analysis

The data from fieldwork was translated and captured in Microsoft Excel Spreadsheet to enable descriptive statistics. XLSTAT was used for descriptive statistics, frequency tables and graphs, and non-parametric statistics for qualitative and not normally distributed data. Chi-square analysis was done using R studio to test the association of columns and rows in tabular data.

A probabilistic technique was applied to determine the number of respondents in the sampling system (Boulares *et al.*, 2018). The researcher synthesized the narrations in the open-ended questions to strengthen the discussion using SWOT analysis. The SWOT analysis method was used, enabling both researchers and participants to highlight strengths, weaknesses, threats and opportunities of a specific study area (Yüksel & Da Tardeviren, 2007). For analysis of the SWOT analysis results, the thematic analysis using Atlas ti8 was carried out. The research is used to highlight, select, and analyze data on themes or trends (Alhojailan, 2012). The information included operational challenges, access to ICT technologies and money to buy, among others. Linear regression was done to see if there was a linear relationship between farmers' age and farming experience regarding adopting the record-keeping application. The data set was, therefore, not appropriate for inferential analysis. The relationship was sought between pairs of awareness, ICT use and ICT use in the innovation chain. The Chi-square analytical method was used to calculate demographic variables and innovations; meaningful dimensions were investigated through cross-tabulations.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 The demographics and farming systems currently implemented by sheep farmers in the Karoo region of the Western Cape.

The socio-economic profiles of the respondents in Eden and Beaufort West districts are depicted in Table 4.1 below. These were age, farming experience in years, household size, gender, educational level of respondents, and farmer status. The findings are shown by the frequencies, counts, tables, and percentages of descriptive statistics.

Table 4. 1. Demographic Characteristics of the Respondents

Variable	Measurement	Frequency	(%)
Gender/Sex	Male	51	96.2
	Female	2	3.8
Marital status	Married	43	81.13
	Single	7	13.21
	Widowed	3	5.66
Level of education	None	6	11.32
	Primary	12	22.64
	Secondary	21	39.62
	Tertiary	14	26.42
Household size	Less than 3	5	9.43
	3-6	37	69.81
	7-10	11	20.76
	Greater than 10	0.0	0.0
Ownership of land	Communal	19	35.85
	Leased	21	39.62
	Private/Own	13	24.53

Age of farmer	30-39yrs	5	9.6
	40-49yrs	12	22.9
	50-59yrs	16	30.3
	60-69yrs	11	20.9
	70-79yrs	6	11.4
	80/>yrs.	3	4.9
Years of farming experience	0-10	17	32.1
	11-20	14	26.5
	21-30	14	26.5
	>30	8	14.9

4.1.1 Age

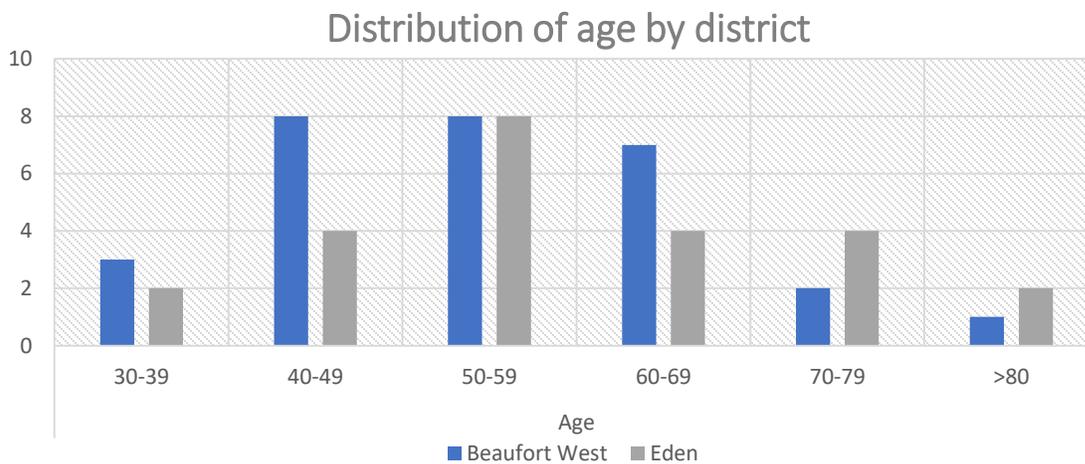


Fig 4. 1. Graph showing the distribution of age by district.

There was no association between age and district ($p = 0.67$) as per the Chi-square results. The mean age of the sheep farmers was 55.4 ± 1.7 . Results (**Fig 4.1**) showed that most of the farmers are above their active years (over 50). Of these participants, 60.38 % were aged 55 years and above with a mean of 63.8 ± 1.43 . At the same time, about 39.62 % were aged below 55, with a mean of 44.3 ± 1.4 . This concurs with literature that suggests farmers in South Africa are mostly above the age of 40 due to the lack of interest from the

youth. Additionally, the migration of young residents searching for better working conditions in urban areas could contribute to this effect (Marandure *et al.*, 2017; Molotsi *et al.*, 2019; The Mail & Guardian, 2020). However, this quantifies the low levels and the lack of interest of young people in sheep farming in Eden and Beaufort West. Age plays a role in farm growth and accessibility of information (Greyling, 2012). This age distribution is one of the key restrictions on the widespread use and implementation of modern farming techniques (Mapiye, 2017).

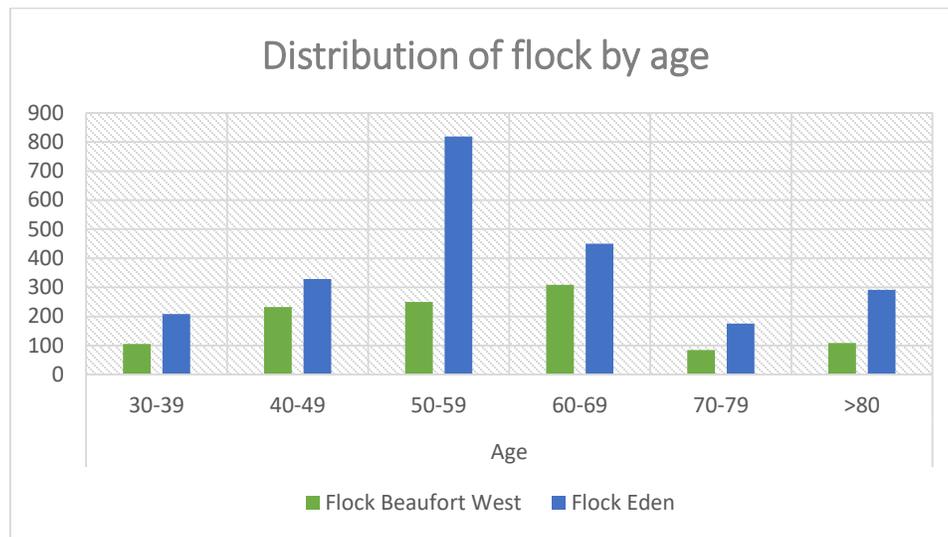


Fig 4. 2 Graph showing the distribution of flock by age per district

According to Fig 4.2, farmers in Eden within the age range of 50-59 years own a large number with a mean of 132.5 ± 36.4 of the sheep flock. Sheep numbers are higher in the Eden district, with a mean of 370.8 ± 94.3 than Beaufort West 180.2 ± 38.9 . This is because most farmers interviewed in Beaufort West were smallholder farmers, and the majority were starting sheep farming, and farmers in Eden were more established with large pieces of land but not yet practising sheep production as part-time and on a small scale for meat and source of income. Approximately 45% of the farmers in Beaufort West highlighted that there were farming, particularly for meat for consumption and as a source of income. Sheep decrease in numbers might also be due to the effects of the Western Cape drought, which made an impact that was devastating for farmers across the province during the 2015-2017 period (Burls *et al.*, 2019). When the drought occurred, pasture and water reserves were below their usual levels, contributing to the flock's starvation and death (ReliefWeb, 2020; Mare *et al.*, 2018).

4.1.2 Gender

There was no association between district and gender ($p = 0.72$). Male farmers dominate sheep farming (**Fig 4.3**) in both Eden and Beaufort West districts, with about 96.2 % of the study participants being males and a relatively low percentage of females involved at 3.8%. However, these findings are contrary to popular belief that most rural areas are women (Chiwawa, 2019). Patil & Babus (2018) in agriculture and rural areas, women's roles and status differ widely from region to age, race, and social class and change rapidly in some parts of the world. Women (and girls) are often responsible for small or young stock, including the diagnosis and treatment of livestock diseases; hence they are involved in animal health interventions and training (FAO, 2010; Thagwana, 2009). Also, it clarified that gender was an important variable to evaluate agricultural positions, obligations, limitations, opportunities, rewards, costs and benefits. Women prefer to work with friendly, manageable, and easy-to-handle animals, to those who can output significantly need more time, attention, and feedback (Quisumbing, 1996). Women also handle poultry and small livestock, while men concentrate on large animals (cattle and sheep) (Udry *et al.*, 1995; Challa, 2015; Patil & Babus, 2018).

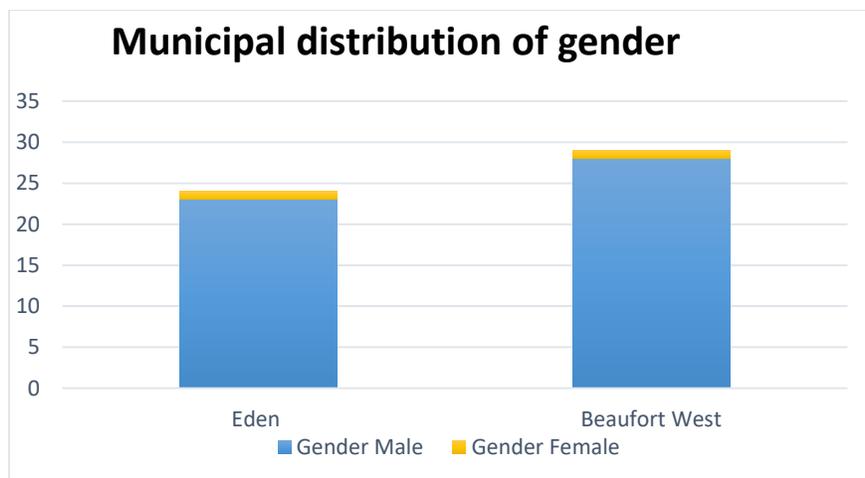


Fig 4. 3 Graph showing the distribution of gender in Beaufort West and Eden districts.

4.1.3 Marital status and household size

In these two districts, the majority of households were male-led. Of the farmers interviewed, 81.13% were married, 13.21 % were single, and 5.66% widowed. This corresponds with Kunene & Fossey (2006)

findings in Northern Kwa-Zulu Natal, where most of the households were headed by male and fewer households were headed by widows or wives of migrants. The mean household sizes for the two districts was 5.1 ± 0.29 collectively. Kumbirai (2016) indicated that household size is advantageous for smallholder farming systems because it guarantees labour availability for farming activities.

4.1.4 Education level

Farmers in both districts, according to the data, are literate. There was no significant association between educational level and the respondents' district ($p = 0.87$). Over 65% of farmers have reached secondary and higher levels, as shown in **Fig 4.4**. This may be as a result of an increase in a variety of fields, such as knowledge access and exposure, a shifting learning climate in South Africa, and more formal practices, such as accessing essential services for adults (Adult Basic Education) (South, Pali & Statistician-General, 2011). This would likely reflect them on-farm recordkeeping, as their respective educational institutions have acquired knowledge and skills. Of the farmers interviewed in Beaufort West and Eden, 88.68% of the respondents had either received lower primary, higher primary, high school qualification or tertiary education.

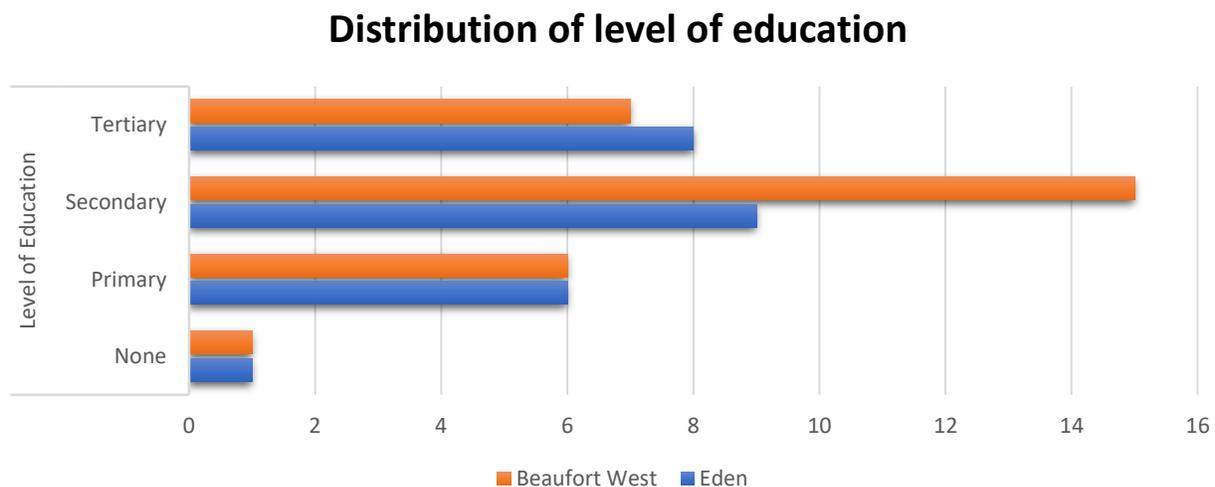


Fig 4. 4 Graph showing the highest qualification attained by respondents per district

4.1.5 Purpose and type of production

The data obtained show that 77.36% of the sheep farmers are producing solely as income sources, whereas 22.64% of the participants produce for multiple reasons (i.e. wool, meat, income and cultural purposes). This finding concurs with Herrero *et al.*, (2015), who also stated that livestock is the leading income source

for smallholder farmers in developing countries. Most of the farmers both in Eden and Beaufort West rear sheep conventionally. Of the farmers interviewed, 12.8% are into the Karoo farming, 22.3% pastoral sheep farming, 4.9% organic and 60% conventional sheep farming (**Fig 4.5**). Pastoral sheep farming is where sheep farmers leave their animals to graze on the natural pasture/ veld, whereas in conventional sheep production, they use the natural veld complemented with planted pasture for sheep feed or bought-in feed. Animals are vaccinated, use antibiotics to treat diseases and hormones for growth in this type of production. Though the Karoo and pastoral sheep farming use natural pasture, Karoo farming only uses the veld that is Karoo certified and bred following the Karoo guidelines and rules. Pastoral and conventional/traditional sheep farming is significant in the two districts because it can be done in drylands where there is no way to grow crops, and this allows for sheep to get sufficient feed in instances of drought and decrease in resources. The Karoo and organic farming respondents totalled 17.7%. The Karoo and organic lamb have laws that safeguard their integrity and importance, and sheep farmers follow the rearing production protocols. To use this phrase, a farmer should produce the Karoo region's norm as farmers undergo audits that demonstrate the Karoo region's authentically produced meat (Du Plessis & Du Rand, 2012; Van der Merwe, Kirsten and Trienekens, 2017, 2018). These rules require free-range grazing or production as a specific necessity. It is recognized as a contributing factor to the taste or sensory qualities of Karoo lamb. The use of growth hormones and supplementary feed is restricted (Erasmus, 2017). In Eden and Beaufort Western, most farmers still use conventional farming practices (82.28%). Farmers explained that they are still using conventional practices because of the Western Cape drought's effects over the years. Farmers, however, sought the need to plant irrigated pasture and supplement feed for their flock as they would die due to low feed levels in the veld.

Type of production

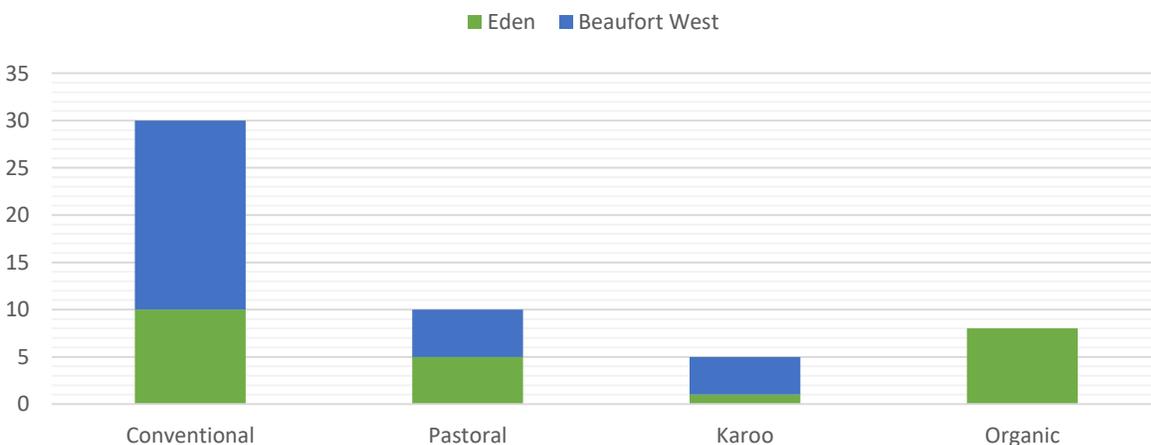


Fig 4. 5 Graph showing the type of sheep production in Beaufort West and Eden

4.1.6 Land ownership

Ninety-two percent of the area in Beaufort West was used as communal land or leased. There was an association between the district and land ownership ($p = 0.049$). A more significant proportion of these farmers (61 percent) farmed on leased land, while approximately 16 percent on privately owned farms. Almost 80 percent of farmers had farm sizes of less than 2,000 ha. However, the scale of the farm ranged from 1 ha to 6420 ha. Beaufort West had more communal farmers, based on traditional structures operated by individuals, without formal training in either animal husbandry or veld management (Sankatane, 2018) compared to Eden. These farms were leased from the municipality and in one area, and the farmers were emerging farmers, most of whom had less than five years in sheep production. Either rented, rented or private in Beaufort West (Fig 4.5). There was an association between the number of animals and farm size ($p = 0.037$). The more land space the farmer had, the greater the flock that was kept. As Mapiye (2009) and Marino (2016) highlighted, farm size dramatically affects the livestock numbers a farmer keeps. For a small piece of land, the veld will be overgrazed if the carrying capacity is exceeded, and destructive grazing would also push farmers to buy animal feed. This is unlikely to increase the efficiency of sheep production and keep the animals alive.

**Fig 4. 6** Graph showing land ownership by sheep farmers in Beaufort West and Eden

Before the record-keeping application was illustrated, farmers were asked about the current record-keeping measures on the farm. The results (Fig 4.7) show that most (38%) of the farmers in Beaufort West and Eden still use individual memory for record-keeping. Individual memory is a recording system whereby farmers know everything by the head rather than physical tools like papers and books. Approximately 19% of the respondents use books, and 32% use paper records as record-keeping forms. The number of farmers using

record-keeping applications like computers (Microsoft Excel) made up about 7% of the respondents. However, this shows no proper record-keeping measures in place in both Eden and Beaufort West communities. However, farmers' training on formal recordkeeping methods is essential as this makes the farmers knowledgeable of their farm productivity (Sankatane, 2018). Farmers should also be trained to understand their products' significance regarding price and the factors that affect pricing. They will also understand how important it is to be certified as organic or Karoo sheep farmers as this would mean more profits to the farmers.

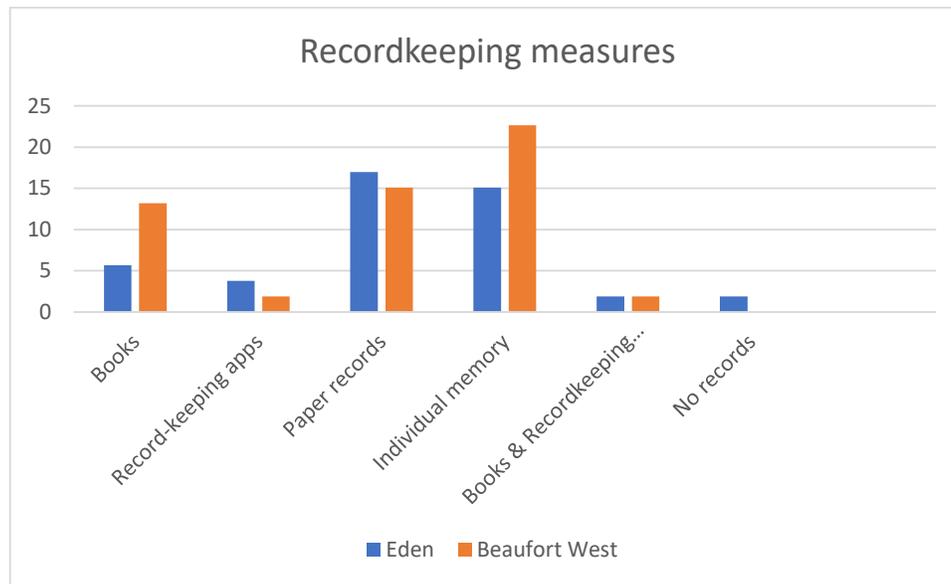


Fig 4. 7: Graph showing the current record-keeping systems in Eden ad Beaufort West

4.2 Perceptions of sheep farmers concerning the Karoo and organic lamb farming

In responding to what they perceive towards the Karoo or organic farming, the farmers highlighted their concerns towards the sustainable sheep practices as discussed in this section. The farmers alluded to the fact that there are disease outbreaks, and they would be forced to vaccinate their animals and, in some cases, give antibiotics. Participant 1 laughed about it, saying:

“I cannot just sit and watch my flock dying. As a farmer, I am forced to be proactive when it comes to my flock. I think I will not be able to survive the rules of the Karoo and organic farming because I am fond of my sheep; I will do anything to keep them alive that entails going against the rules.” (Laughs)

Participant 2 emphasized the need for proper records when one needs to register as a Karoo or organic sheep farmer:

I want to move from this type of production to a more sustainable way, yes. The only problem is the records. I am not up to date with my records, and I know that always pulls me down. Now that you mentioned the recordkeeping application, I can use it and apply to be a Karoo or organic farmer.

About 65% of the sheep farmers concurred with what participant 3 said about organic or Karoo sheep farming:

I have limited pasture, so I slaughter my flock to reduce numbers on the farm. Our sheep have exceeded the grazing capacity over the years.

The concerns of 80% of the farmer coincide with literature from Chiyangwa (2018) that farmers in the Karoo are switching from sheep to horticultural production or other land uses due to low sheep productivity. The farmers emphasized that they face challenges from lack of adequate food and exposure to harmful conditions, for example, climate and high risk of diseases. This problem can be mitigated by providing shepherds (Chiyangwa, 2018), with which the farmers also stressed that it increases labour costs.

Participants 4 and 5 (respectively) had this to say about their perceptions towards the Karoo and organic farming:

“You see, nothing can survive this poor pasture, even us humans. There is nothing but dead bushes and rocks. Vegetation on its own cannot survive these harsh conditions, what more livestock. So I supplement with planted pasture by all means possible.”

“At first, I was procrastinating because I do not have the skills to keep good records of my sheep flock, but then I had to downscale because I could not watch my flock dying, and I could not achieve to feed my flock. So yeah, supplementing with concentrate and pasture was a better option.”

4.3 Strength, Weaknesses, Opportunities and Threats of the recordkeeping application highlighted by farmers in Beaufort West and Eden districts.

4.3.1 Themes from the Interview Data

In analyzing the interview data, themes that form the strengths, weaknesses, opportunities and threats of the recordkeeping application emerged, as discussed in this section. These themes were: the importance of using recordkeeping software, improving sheep farming and analyzing farm information. In the interviews, the data reveal that sheep farmers in Beaufort West and Eden were all seeking ways to improve their sheep farming methods and achieve better yields.

Participant 1 suggested that with training, the application would bring him desirable results on his farm. He discussed this change:

"One thing I like about the app is how it enables me to collect data directly to my phone, say when I am on the farm, which means I will not forget to record information, and it is more important for performance. It will also allow me a better chance to make proper and good decisions on the farm, with the use of updated records."

Participant 2 highlighted that he is keen to enter the market as a commercial sheep farmer. He had this to say about the new system of recordkeeping:

"As a small farmer (currently), I would like to enter the market and using the recordkeeping application would be helpful since traceability will be made easier and using the application helps to get support and help from the banks and other organizations."

These comments seem to provide evidence that participants 1 and 2 liked the idea of the new system of recordkeeping for two reasons. First, the ability to identify changes the application will bring to him and the farm as a whole, and second, his expressed beliefs are congruent about recordkeeping and the practice he describes.

4.3.2 Strengths

Table 4.2 describes the perception of farmers concerning the strength and importance of the recordkeeping application. The strengths were assumed and ranked or weighed as follows: improving recordkeeping standards, improving decision making through access to improved records, data access and connectivity, digital skills for operating the application system and helps in determining which enterprise is profitable and the user-friendliness of the application were accepted as importance with a weighted mean score. Other assumed strengths that scored a weighted critical mean of less than 3.0 were not the farmers' importance of farm records. Such factors are; digital skills needed to operate the application and help determine which enterprise is most profitable. This assumed importance had no direct importance to the farmers since most farmers are farming for consumption, income and personal reasons, so there was no need to compare with what other farmers are doing. Also, most farmers believed that digital skills were less necessary to learn how to use their devices.

Table 4. 2: Farmers' Perception on the Strengths of the Recordkeeping Application

Assumed strength/importance	No of Respondents	Weighted score	Weighted Average (X)	Remark
It helps improve recordkeeping standards	53	242	4.56	**
Easy to use (user-friendly)	53	210	3.96	**
Data access	53	163	3.07	**
It helps to identify which enterprise is most beneficial.	53	146	2.75	*
Digital skills	53	134	2.5	*
It helps in analyzing the performance of the farm (decision making)	53	233	3.8	**
Critical mean			3.0	$\geq 3.0 = **$ $< 3.0 = *$

Field Survey, 2020 (Eden and Beaufort West), **Accepted as important, * Not accepted as necessary.

4.3.3 Weaknesses

Farmers also regard recordkeeping as a global challenge (Tham-Agyekum, Appiah and Nimoh, 2010) (Poggio, 2006). While Muhammad *et al.*, (2004) demonstrated that keeping farm records is vital for very effective farmers, sheep farmers in Eden and Beaufort West do not currently keep all farms records. Essentially, farmers face constraints that underlie their failure to maintain farm records even before the recordkeeping application has been introduced. Most of the reasons (80%) were based on the time taken to keep records up to date. Other reasons provided by sheep farmers as to why they have recordkeeping problems included; difficulty entering data into record books due to stress, forgetfulness due to deferred entries (15%), hired personnel who keep farm records cheat on their managers, and some workers find it difficult to enter data because of their low educational attainment (5%). While at this level, the farmers know the importance of recordkeeping and its practical application in diverse farms, the weakness of not keeping up with technology was significant as compared to failures in bookkeeping that do not need updates (software). Some of the concerns towards the farmers' recordkeeping application are shown in Fig 4.6 below,

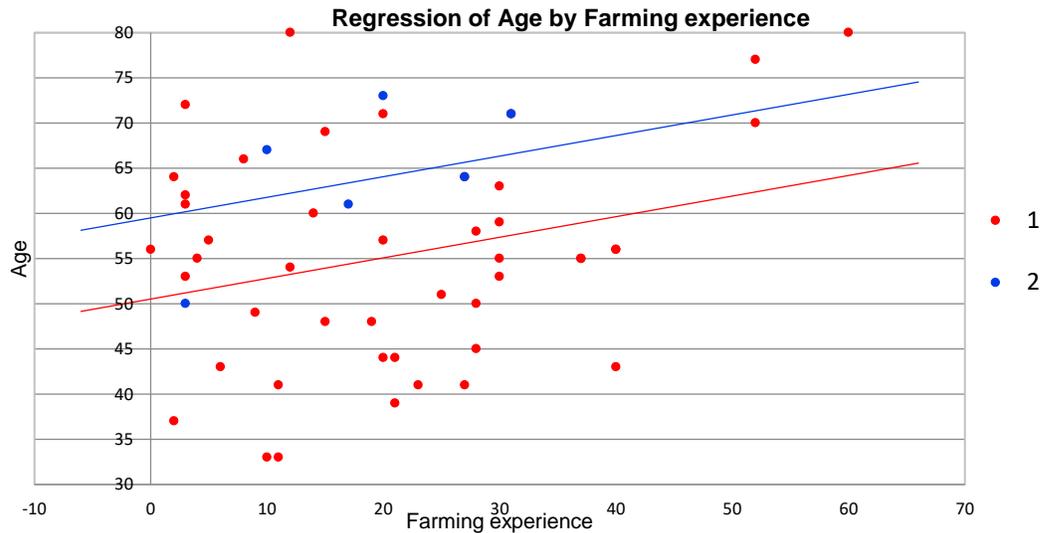


Fig 4. 11: Logistic regression showing the relationship between age and farming experience by district. **1 = Yes, 2 = No

There was no association between adopting ICT against farmers age, digital skills and data constraints (Table 4.3). P-value of age for all variables > 0.05 (confidence interval) there is evidence that age is not a determining factor (predictive) for the adoption of the recordkeeping application. The odds ratio of 1.67 means that in one group, the outcome is 67% more likely to be affected by education level in operating the application. Also, for the user-friendliness of the application, an odds ratio of 0.95 was obtained, meaning there is a low level of precision in the likelihood of education affecting the user-friendliness of the application. The age, level of familiarity, and education level are less likely to affect the application's digital skills and user-friendliness.

Table 4. 3. Odds ratio results

Factor	Odds Ratio		
	Age	Level of education	Level of familiarity
Digital skills to operate app	0.39	1.67	0.51
User friendliness of app	0.40	0.95	0.3
Data constraints	0.27	0.32	0.43

4.5 Willingness to adopt the record-keeping application

A Chi-square test was performed to assess the association between willingness to adopt the application and possible constraints. The farmers' willingness to adopt the recordkeeping application and the results were shown in Table 4.4 below. The test results showed no significant association between the adoption of the recordkeeping application and given constraints. The association test results show that there are differences between districts regarding the level of familiarity and adoption. In this case, all the p-values were significant at 0.05, which gives evidence that variables are dependent. This might be because farmers are not used to having digital records and used to the traditional way of keeping records. The district or municipality the farmers came from also influences the adoption of the application. Reasons behind the effect might be that the farmers in one of the districts are not willing to switch from traditional ways of recordkeeping to digital applications. This might also be due to land use and the purpose of most farmers' production, giving rise to these results. Land ownership and type of production also influence the adoption of the new recordkeeping application. However, overall 79% of the sheep farmers in the Western Cape were willing to adopt and use the recordkeeping application.

Table 4.4. Association test results (Chi-square)

Factor	p-value
Association between the level of familiarity with recording applications and willingness to adopt the application	0.006
Is district/municipality associated with willingness to adopt the application?	0.004
Does land ownership have an association with farmers' recordkeeping app adoption?	0.007
Is there an association between sheep production type and purposes with the adoption of the application?	0.022

Conclusion

The study results showed that sheep farmers in the Western Cape face recordkeeping problems, affecting certification (the Karoo and organic lamb). Farmers understand the purpose of recordkeeping if they want to process certification, but the primary constraints are the high prices they pay to get smartphones or computers (or any other ICT) used for recordkeeping. When launched, the Sheep Breeding Management

application can be a good way of mitigating these problems raised by farmers. The application is user-friendly, and farmers could submit basic breeding information that links with other farmers in their areas. Paper records are also difficult to keep track of as they are easily destroyed or lost. It is, therefore, necessary for the government and research institutions to take a leading role in trying to provide appropriate solution measure to these challenges, coming up with ways to reach the needy farmers with devices relevant for recordkeeping and training. Apart from such government initiatives, assessing the need to improve the individual farmers' management skills by using technological tools and models that facilitate the creation and sharing of extension messages is encouraged. The drought and space for grazing are significant factors hindering the sheep farmers from transitioning from current sheep production practices to Karoo or organic lamb farming. However, if proper and formal recordkeeping measures are in place, productivity in sheep farming increases as management is made easy. Certification of farmers to be identified as the Karoo and organic sheep producers is made possible, allowing for increment in farmers' profits. Other on-farm measures can be put in place, making record-keeping a less tiring job, including sheep tagging for identification purposes, regular weighing and records of feed, and health management that can be stored in the applications contributing to sustainability in smallholder sheep farming.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

The study aimed to determine the use of ICT technologies to encourage sheep farmers to record data and, as such, be able to enter the niche market of organic and Karoo lamb. To aid smallholder sheep farmers to ensure sustainable sheep production using a recordkeeping application. This recordkeeping application will be used for quality control and better management decisions for sheep farmers in Beaufort West and Eden communities. The application will support farmers in keeping records and improving sheep production, and mitigating poor tracking methods. Farmers highlighted the difficulties and importance of the recordkeeping application and whether they could adopt the application for recordkeeping purposes.

The first objective was to determine demographics and farming systems implemented by smallholder sheep farmers in the Western Cape. There was an association between the farmer's age, the degree of familiarity with ICT, the district and the willingness to adopt the application for recordkeeping. The younger the farmer was, the more the farmer was interested in using ICT. The results also showed no influence from years of farming experience and age to adopt the recordkeeping application. Around 12% of the farmers were practising Karoo lamb farming, approximately 4.9% were into organic farming, and 60% into conventional sheep farming. Conventional sheep farming allows for farmers to grow pasture, vaccinate, inject with hormones and supplement feed, among others. In contrast, the Karoo and organic sheep farming is for animals that graze natural veld, bred using the Karoo rules and regulations (for the Karoo certified lamb) and organic sheep, feed on certified organic feed under practices guidelines of organic farming.

The second objective was to draw smallholder sheep farmers' perceptions on implementation and use of the recordkeeping application following farmer implementation engagements. This was achieved by noting the farmers' expectations and ability to begin using the recordkeeping application. The farmers' responses clarified that it was time-consuming and tiring to use pen and paper and were keen to adopt and use the recordkeeping application for their farm records since it can be used even on phone gadgets which would mean less burden in carrying stationery to the fields and also there will be no need to memorize information when an application is readily available.

The third objective was to determine factors that influence ICT adoption, which identified strengths, weaknesses, opportunities, and threats using SWOT analysis. The farmers emphasized that the critical problems farmers described are the lack of time needed for the transformation process and access to network systems and gadgets. The application will help them keep track of their farm record and thereby contribute to the farm's productivity. High farm productivity leads to high income/profit levels. Regardless of the

constraints they put across, farmers interviewed expressed that they were willing to adopt and use the application for record-keeping purposes. Information, computer and technology skills and poor network connection influence ICT use in Eden and Beaufort West. Thus, initiatives that improve the livelihood of farmers in the Western Cape are needed.

The results from the association tests indicated that the degree of familiarity and acceptance varies between districts. This may be because farmers are not used to the way of documenting digital records. The district or municipality from which the farmers came also affects the application adoption. The explanation behind this may be that farmers in one district cannot move from the old recordkeeping methods to digital recordkeeping (use of ICTs). However, sheep farmers are willing to transition from conventional farming systems to the Karoo and organic production if land and space are available. The recording application could benefit both the farmer and the consumer for traceability purposes in this regard. In addressing economic sustainability, the record-keeping system will aid in improving profitability and productivity. If records are well documented, marketing of sheep produce will be easier for smallholder sheep farmers and thus increase higher incomes.

Conclusion

Achieving sustainable sheep production can be possible by adopting a record-keeping application by smallholder sheep farmers, which will assist producers in logging their activities and production systems on the farm. This will aid in transitioning from conventional to organic or Karoo sheep farming which are more environmentally sustainable ways of sheep farming. Record-keeping is a valuable way for all producers to improve market and resource management. The technical feasibility of the record-keeping application brings about sustainability in a way that connects and links smallholder sheep farmers through sharing of farm information and data. Smallholder sheep farmers will also learn how others produce and work on using these techniques on their farms. It will bring farmers together in groups (for example, cooperatives) and other networks. Also, looking at reliability and self-reliance of the record-keeping application addressed that will aid in achieving improved production and productivity, farmers need to be more informed about the farming systems. In Western Cape, sheep farmers have poor internet connectivity and an inadequate supply of electricity. Farmers rely on information from the Agriculture Department to mitigate these problems. Adopting ICTs in this instance brings about fewer hustles and struggles in obtaining information since sheep farmers can easily access the information they need from record-keeping applications. It is also socially sustainable to use ICTs as they link the farmers to sheep data and links farmers to other sheep farmers who perform well or have problems sharing ideas and information concerning production. Sheep farmers in the Western Cape (Eden and Beaufort West) are willing to use the

application and are excited to experience the latest technology. Though farmers consider record-keeping as time-consuming, keeping track of what is happening on the farm is one of the most important aspects to improve animal welfare and farm management, and the use of ICTs for record-keeping purposes like cell phone applications address the issue of time since it can be done even in the field. Also, keeping records of all the activities carried out within the farm may allow them to avoid financial losses, make more informed decisions, and help farmers transition from conventional/traditional sheep farming systems to the Karoo and organic farming.

Recommendations

From this study, it can be concluded that interventions to improve smallholder sheep farmers' sustainability in both communities are wanted. The introduction of the recordkeeping application can overcome problems affecting sheep production in the Western Cape. In this regard, it can be recommended that:

- Considering including or translating the app language to Afrikaans, most of the Western Cape farmers are Afrikaans.
- Consider coming up with a database that farmers can access at any given time. It should give other animals' sales on various farms, the growth and reproduction information, and information on stud breeders.
- Additional information on the gender of animals should be included (castrated or not)
- The recordkeeping application should also include the health status of animals and integration of veld management and carrying capacities (and on the farm side highlight if the pasture is irrigated, natural)
- Make the application simple for farmers and add some valuable statistics and benefits for the poor farmers and those who cannot afford smartphones (warning SMSs)
- The recordkeeping application is introduced to sheep farmers once the development process is done.
- The development of applications and databases that are not only for sheep farmers but also for other livestock farmers (beef, poultry, dairy, piggery)

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Section B: Farm Information/Afdeling B: Inligting oor die Plaas

- i. Farm Naam/Plaas Naam.....
8. How long have you been farming at this farm? /Hoe lank boer U by hierdie plaas?.....
9. Size of farm/Grootte van plaas (ha) Total/Totaal.....
Arable/Bewerkbaar.....
10. Distance from farm to nearest Abattoir/Aftstand vanaf plaas tot naaste slaghuis.....
11. Land ownership/Grond eienaarskap Private of Own/Privaat of Eie Communal or Tribe/Gemeenskaplik of Stam) Lease/Huur
12. How did you acquire the land/Hoe het U grond bekom?.....

Section C: Production Information/Afdeling C: Inligting oor die Produksie

Description of production system (tick)/ Beskrywing van produksie sisteem (maak 'n merkie)	
Pastoral/Pastoraal	
Mixed-crop livestock/Gemengde gewas en vee	
Free range/Vrylopend	
Other(specify)/Ander (spesifiseer)	

Livestock enterprises/Vee ondernemings	Number of Animals/Hoeveelheid diere	Main breed(s)/Hoof ras(se)	Rank (1-3)/Rang (1 – 3)
Sheep/Skape			
Cattle/Beeste			
Chicken/Hoenders			
Pigs/Varke			
Goats/Bokke			
Other(specify)/Ander (spesifiseer)			

Reason for sheep production (tick)/Rede vir skaapproduksie (maak 'n merkie)		Rank (1-3) /Rang (1 – 3)
Income/ <i>Inkomste</i>		
Saving or asset/ <i>Spaar of bate</i>		
Wool production/ <i>Wol produksie</i>		
Manure source/ <i>Kunsmis</i>		
Meat source/ <i>Vleis</i>		
Cultural/ <i>Kultureel</i>		
Other (specify)/ <i>Ander (spesifiseer)</i>		

13. How would you define your sheep production practices? /*Hoe sal U die skaap produksie praktyke definieer?*
14. Do you practice organic farming? /*Boer U organies?* Yes No
15. If yes to Q14, briefly describe your organic farming system /*Indien ja vir vraag , beskryf kortliks U organiese boerdery praktyke*
-
- ..
16. What are your perceptions of organic lamb farming and certifications?
-
-
-
17.
-
-
18. Are your livestock products karoo certified? /*Is U vee produkte karoo gesertifiseer?* Yes/*Ja* No/*Nee* Processing certification/*Proses sertifisering*
19. If yes to question 16, briefly describe the karoo farming system /*Indien ja vir vraag 25, beskryf kortliks die boerdery sisteem*
-
-
20. What are your perceptions of Karoo lamb farming and certifications?
-
-
-
21. Does the farm have record keeping measures in place /*Het die plaas enige recordhouding maatreëls in plek?* Yes/*Ja* No/*Nee*
22. If yes for question 19, in what ways are records kept on the farm? /*Indien ja vir vraag , op watter wyse word daar record gehou?*

Individual memory/*Individuele geheue*

Paper records/*Papier rekords*

(Books/Farm registers)/(*Boek/Plaas registers*)

Recording applications (e.g. computer, mobile etc...)/*Record toepassing (bv. rekenaar, mobiele toestel ens...)*

Other(specify)/*Ander (spesifiseer)*

23. Would you consider using ID tags as means for recordkeeping? /*Sal U ID etikette (tags) gebruik as rekordhouding middel? Ja/Nee*

24. Would you consider using a computer system as means for recordkeeping? /*Sal U 'n rekenaar sisteem gebruik as rekordhouding middel? Ja/Nee*

25. Do you know of any ICTs used in sheep farming? /*Weet U van enige ICTs wat gebruik word in skaap boerdery? Ja/Nee*

Question/Vraag	Yes/Ja	Explain/Verduidelik	No/Nee
Do you grow crops used for sheep feed? / <i>Groei U gewasse vir skaap voer?</i> Do you use fertilizers (synthetic) for planted pasture? / <i>Gebruik U kunsmis (sintetiese middels) vir weiding?</i> Do you buy your sheep feed? / <i>Gebruik U enige byvoer vir die skape?</i>			
Do you use karoo approved practices and materials to maintain pasure soil? / <i>Gebruik U karoo goedgekeurde praktyke en materiale om weidingsgrond te onderhou?</i> Do you used organic approved practices and materials to maintain pasure soil? / <i>Gebruik U organies goedgekeurde praktyke en materiale om wiedingsgrond te onderhou?</i>			
Do you farm with local sheep breeds? / <i>Boer U met plaaslike skaap rasse?</i>			
Do you use antibiotics? / <i>Gebruik U antibiotiese middels?</i> Do you use growth promotors of hormones? / <i>Gebruik U groei promotors/hormone?</i> Do you use vaccinations? / <i>Gebruik U entstowwe?</i>			

26. If yes, provides details about the ICTs and its uses/ *Indien ja, verskaf besonderhede oor die ICTs en hul gebruike*

.....

27. Have you used any of the applications or systems you mentioned above/*Het U al enige ICT toepassings of sisteme, wat hierbo genome is, gebruik? Ja/Nee*

28. If yes, explain how and what you have used the applications for/*Indien ja, verduidelik hoe en waarvoor U die toepassings gebruik het*

.....
.....
.....
.....

29. Are you familiar with recordkeeping softwares and their roles in sheep production/*Is U bekend met rekordhouding sagteware en toepassings in skaap produksie* Yes/*Ja* No/*Nee*?

Level of familiarity/*Vlak van bekendheid* : Advanced/*Gevorderd* Intermediate/*Intermediaat*
Low/*Laag*

30. If you have answered yes to question, how was/has your experience been using the application/*Indien U Ja geantwoord het vir vraag , hoe is/was U ervaring met die gebruik van die sagteware/toepassings?*.....

.....
.....

31. If you have answered no to question 28, what is your view towards the importance of using an application for recordkeeping in sheep production? /*Indien U nee geantwoord het vir vraag 28, wat is U siening teenoor die belangrikheid met die gebruik van 'n toepassing vir rekordhouding in skaap produksie?*

.....
.....
.....

32. What are the possible challenges/constraints you face in recordkeeping? /*Wat is die moontlike uitdagings/beperkings wat U in die gesigstaar met rekordhouding?*.....

.....
.....

33. If you do not have/use a record keeping software/application. List the reasons why you might not have, use or have access to them/*Indien U nie 'n rekordhoudingssagteware/toepassing het of gebruik nie, lys die redes waarom U nie dit het, gebruik of toegang het tot dit nie*.....

.....
.....
.....
.....
.....

Part B. Perceptions of farmers towards the adoption of application

Deel B. Boere se persepsies oor die aanmeming van die (ICT) toepassing

Instructions: This part of the questionnaire is designed to assess farmers' perceptions regarding recordkeeping software. Please read the statements and indicate how much you agree or disagree with each statement by circling an appropriate response category.

Instruksies: Die deel van die vraelys is ontwerp om die persepsies (siening) van boere oor die gebruik van 'n sagteware vir rekordhouding te assesseer. Lees die stellings hieronder deeglik deur and dui aan tot watter mate U met elk van die stellings saam stem deur 'n sirkel om die geskikte kategorie te trek

Circle "1" if you **strongly disagree** with the statement, and circle "5" if you **strongly agree** with it.

Sirkuleer "1" indien U glad nie saam stem met die stelling nie en "5" indien U heeltemal saam stem met die stelling

Use the following rating scale/ *Maak gebruik van die volgende rangorde:*

1= Strongly Disagree/Stem glad nie saam nie

2= Uncertain/Onseker

3= Neutral/Neutraal

4= Agree/Stem saam

5= Strongly Agree/Stem heeltemal saam

1. The proposed recordkeeping app will improve my recordkeeping standards

Die voorgestelde rekordhoudingstoepassing sal my rekordhou standarde verbeter

5 4 3 2 1

2. The app will improve my decision making through access to improved records

Die toepassing sal my besluitneming weëns toegang tot verbeterde rekords verbeter

5 4 3 2 1

3. It will be difficult for me to use the app because data is expensive

Dit sal moeilik wees vir my om die toepassing te gebruik omdat data duur is

5 4 3 2 1

4. I do not have the digital skills to operate such an application system

Ek het nie die digitale vaardighede om so 'ntoepassingsstelsel te gebruik nie

5 4 3 2 1

5. The app is user friendly and easy to use

Die toepassing is gebruikersvriendelik en maklik te gebruik

5 4 3 2 1

6. From the discussion we had about the recordkeeping app, are you willing to adopt and use the recordkeeping application? Yes/ No

Van die besprekings wat ons gehad het oor die rekordhoudingstoepassing, is U gewillig om die toepassing aan te neem en te gebruik? Ja/Nee

7. What Strengths, opportunities does the application

have?.....
.....
.....

8. What challenges, weaknesses (threats) are you likely to face using the record keeping app?/

Watter uitdagings kan U moontlik in die gesig staar deur die toepassing te gebruik?.....
.....
.....

Appendix 2: Chi-square analysis results

1. Pearson's Chi-squared test

data: Age

X-squared = 4.0456, df = 6, p-value = 0.6705

2. Pearson's Chi-squared test

data: level.of.educa

X-squared = 1.2717, df = 4, p-value = 0.8662

3. Pearson's Chi-squared test[p56

data: land_ownership

X-squared = 14.125, df = 3, p-value = 0.002739

4. Pearson's Chi-squared test: level of familiarity against adoption

data: familiarity_adoption

X-squared = 12.419, df = 3, p-value = 0.006078

5. Pearson's Chi-squared test: district against adoption

data: district_adoption

X-squared = 10.897, df = 2, p-value = 0.004302

6. Pearson's Chi-squared test: land ownership against adoption

data: land_ownership

X-squared = 11.969, df = 3, p-value = 0.007489

7. Pearson's Chi-squared test

data: familiarity

X-squared = 11.399, df = 4, p-value = 0.02243