University of KwaZulu-Natal

Acceptability of Radiofrequency Animal Identification in Rural KwaZulu-Natal

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DECLARATION

I, Isaiah Mahlolani Mahlangu solemnly declare that the work contained in this thesis is original. It was conducted as partial fulfilment of the MBA with the Graduate School of Business and Leadership, University of KwaZulu–Natal, under the supervision of Professor Muhammad Hoque. Scientific evidence supporting this study has been referenced appropriately. This work has not been submitted for another degree or to any other tertiary institution.

Signature of Student

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Isaiah Mahlolani Mahlangu Date 17 June 2018

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ABSTRACT

The outbreak of animal diseases occurring in the past decades resulted in food incidents affecting animal products across the world. The subsequent decline in consumer confidence and profit losses forced the beef and dairy industries to improve production management. A “farm-to-fork” traceability system in the form of Radiofrequency Identification (RFID) was adopted by many global markets as a solution. Invented to monitor military aircrafts during the World War II, RFID has transformed the traditional animal identification methods first practiced some 3 800 years ago. Other industries have also adopted RFID to improve efficiency in the supply chain. In beef production, RFID also has the potential to deter stock theft. There is insufficient evidence of how this technology is accepted by the emerging markets, particularly among rural livestock farmers.

This study was motivated by the plan of the Department of Agriculture Rural Development to introduce RFID animal identification in rural areas of KwaZulu-Natal (KZN), South Africa. The aim of the study was to test acceptability of RIFD by livestock farmers in rural areas of KZN. A quantitative approach was used to conduct a descriptive survey among the livestock farmers at Msinga, a Local Municipality in the Umzinyathi District of KZN. Data was collected from 170 randomly selected participants from a population of 1 000 livestock farmers. The study revealed that animal identification at Msinga is based on the use of skin colour, naming of animals, unauthorised random brand marks and authorised systematic brand marks. This approach seeks to enhance animal identification and ownership. The literature review showed that in spite of the evidence that countries without traceability systems fail to gain access into lucrative international meat markets, South Africa has not adopted RFID.

Based on the Chi-Square test, the study fails to accept the null hypothesis suggesting that livestock farmers will not accept RFID. At 95% level of significance, the study concludes that there is sufficient evidence suggesting that livestock farmers at Msinga will accept RFID. As the beef industry migrates towards traceability to achieve product differentiation, gain consumer confidence and competitive advantage, it is recommended that South Africa consider a

legislative framework to enable the adoption of RFID by livestock farmers, and that the government support the introduction of this technology into communal farmers in rural areas.

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ABBREVIATIONS

BSE	*Bovine Spongiforum Encephalopathy*
BTEC	Brucellosis and Tuberculosis Eradication Campaign
CCIA	Canadian Cattle Identification Agency
CRM	Customer Relationship Management
FANMAS	Farm Assured Namibian Meat Scheme
FAO	Food and Agriculture Organisation
FMD	Foot and Mouth Disease
HF	High Frequency
ICAR	International Committee for Animal Recording
ISO	International Organisation for Standardisation
LF	Low Frequency
LITS	Livestock Identification and Trace-Back System
NAIS	National Animal Identification System
NAIT	National Animal Identification and Tracing
NBIT	National Bovine Identification and Traceability
NamLITS	Namibian Livestock Identification and Traceability System National
NLIRTS	Livestock Identification, Registration and Traceability System
NILS	National Livestock Identification System
OIE	World Organisation for Animal Health
QAS	Quality Assurance Standards
RFID	Radiofrequency Identification
SCM	Supply Chain Management
SGS	Argentina Animal Health Information System
SINIGA	National Livestock Individual Animal Identification System
SISBOV	Brazilian System of Identification of Bovine and Buffalo Origin
SNIG	National Livestock Information System
SPSS	Statistical Package of the Social Sciences
UHF	Ultra high Frequency
WTO	World Trade Organisation

Chapter 1 : Introduction

1.1 Introduction

Radiofrequency Identification (RFID) is increasingly being adopted by livestock producers worldwide to improve production management practices, consumer confidence and the market share. The adoption of RFID by the markets of well developed economies incorporation and use of RFID with positive gains. While emerging economies are gradually adopting this technology in different industries and livestock production in particular, the intake is hampered by a range of economic structural impediments as well as attitudes of farmers. In an around 2012, the Department of Agriculture and Rural Development announced plans to introduce RFID to support livestock producers in rural areas. This plan prompted a study to investigate the acceptability of RFID by livestock farmers in rural areas. In addressing this question, the study explored the context of RFID focusing on enablers and constraints at international level in general and in South Africa in particular.

The RFID might be regarded as a relatively new technological innovation. However, empirical evidence shows that RFID gained prominence during the World War II where it was used to monitor aircrafts and enhance military operations. A wide spectrum of industries that are involved in manufacturing and distribution of products have gradually incorporated RFID in their value chain to enhance traceability systems. This Chapter presents the historical context of the study and justification for undertaking this research exercise. The purpose of this Chapter is to introduce the subject matter, justification of the study and the use of RFID in animal production as an instrument to enhance traceability systems.

1.2 Historical Context of RFID

For centuries, livestock farmers around the world have practiced some or another form of animal identification as evidence of ownership. A strong sense of ownership helped farmers to present convincing evidence in courts of law with respect to stock theft cases. In recent years, there have been new triggers which required further improvements with respect to animal identification. The food safety incidents occurring globally over the past decades have resulted in consumers increasingly demanding assurance on quality and food safety (Shanaham, Kernan et al. 2009). In the 1990s, the outbreak of *Bovine Spongiform Encephalopathy (BSE)* or “mad cow disease” resulted in a 10 (ten) year ban of beef and dairy exports from Europe (Trevarthen 2007). Similarly, the outbreak of H5N1 in certain parts of South Africa and the 2011 Foot and Mouth Disease (FMD) outbreak in KwaZulu-Natal, resulted in a 3 (three) year export ban and a loss of R 4 billion worth of trade during that period (Olivier, Fourie et al. 2006, GAIN 2014).

In pursuit of a solution to this complex problem, RFID was identified as a technology to improve and control production management in order to guarantee food safety. The introduction of the RFID implied significant transformation from what was once a simple method of animal identification into a more complex technological system of traceability. The RFID is recognised by the Worldwide Organisation for Animal Health (OIE) and International Committee for Animal Recording (ICAR) among other international organisations (OECD 2008). This technology has been adopted by many well developed global economies to improve disease surveillance and to respond quickly to animal disease outbreaks. With exception to a few countries like Botswana, Namibia and Tanzania, emerging economies particularly in the African Continent appear to trail behind. South Africa is among the countries that have not yet adopted the animal identification and traceability system. This is confirmed by the fact that the Animal Identification Act (Act No 6 of 2002) categorically exclude ear tags and electronics as methods of animal identification (Republic of South Africa 2002).

Implementation of RFID is associated with a number of benefits including the ability to enhance food quality and safety, penetration to premium markets, building consumer confidence, product differentiation and economic gains. The absence of traceability attracts market barriers particularly in the event of viral animal disease outbreaks. Implementation of RFID has not been without challenges. There is empirical evidence of reluctance to the use of RFID among farmers, especially in the United States (Skaggs 2011). This is because implementation costs are massive, but also, some farmers have suspected governments implementing RIFD with hidden motives (Skaggs 2011). In Botswana the system once suffered from lack of cooperation of stakeholders in the supply chain.

Animal identification and traceability systems have undergone at least two major phases. The first phase was a manual based animal identification method. This phase was associated with a very simplistic form of animal identification which aimed at ascertaining proof of ownership, through applying random brand marks on animals. The second phase is technologically based and involves very complex animal identification methods. This phase is aimed at ensuring traceability of products, managing animal disease outbreaks, improving distribution efficiency through the supply chain and ensuring quality and food safety. This is achieved through improving traceability of animals and products using RFID technology. In both cases, domestic laws and international guidelines have been put in place to maintain standards and practices of animal identification and traceability systems. Failure to comply with domestic laws attracts penalties. At the same time, operating outside the traceability framework has consequences. Producers of food products encounter difficulties penetrating premium markets in well developed economies. Also, in the event that there is viral animal disease outbreak, the beef and dairy industry is often banned from export trade.

In South Africa, animal identification is regulated by the Animal Identification Act (Act No 6 of 2002 (Rebuplic of South Africa 2002). In terms of this Act, individual livestock owners are obligated to brand animals (Republic of South Africa 2002). Anecdotal evidence and observations on livestock in rural KZN suggests that livestock owners barely comply with this Act. It is also worth mentioning that in spite of the Animal Identification Act, livestock theft in KZN is prevalent (Department of Community Safety and Liaison 2008). Lack of compliance with the Animal Identification Act makes it easy for thieves to steal animals since ownership can easily be disputed even in a court of law.

The Department of Agriculture and Rural Development (DARD) in KwaZulu-Natal, has a plan to introduce RFID among the livestock farmers in the rural areas of KZN. This would require considerable resources and effort. Livestock production in KZN takes place in a dual system; in a controlled environment in commercial farming systems and in a free ranging system in communal rural lands. Given that rural farmers keep 52% of livestock (cattle, goats and sheep) compared to 48% in commercial farming, animal identification and traceability systems will need to prioritise communal farming areas. This intervention would bring about a drastic change in livestock production management practices.

1.3 Problem statement

The successful implementation of RFID in KZN will ensure that the region is at par with global animal identification and traceability systems. However, the plan by the DARD to support farmers migrate from traditional animal identification to the RFID is dependent on a number of variables. There are obstacles that would need to be managed. Poor compliance with the current Animal Identification Act, might imply that there would be slow uptake of this technology. Livestock farmers without access to technology will be alienated from the benefits of this programme. There is evidence that even in well-developed economies livestock farmers have been reluctant to adapt to the RFID on the basis of increased production costs. Also, during animal disease outbreaks, countries without advanced traceability systems may be banned from the global meat markets. There is one more hurdle to deal with. Acceptability of technological solutions is an important factor in the equation.

1.4 Motivation of the study

This study was motivated by the interest to test whether in a world affected by challenges of stock theft, market scepticism; would technological solutions in livestock production be practical in rural areas of KZN. The approach to test this question was to assess the level at which RFID would be accepted by livestock farmers. The interest was also to assess the level of acceptability in rural areas of South Africa when even in some well-developed economies acceptance level is low. This is even more compelling in consideration of the fact that the study area is associated with high levels of illiteracy and poverty.

1.5 Research Objectives

The study aimed to achieve the following objectives:

(i) To understand the current animal identification and traceability systems among communal farmers at Msinga;

(ii) To investigate the effectiveness of the current animal identification on traceability of meat products; and

(iii) To test whether farmers will accept RFID as a solution to improve animal identification and traceability system.

1.6 Research Questions

To address the objectives of the study, the following broad questions were asked:

(i) What are current animal identification and traceability systems among communal farmers at Msinga?;

(ii) Is the current animal identification effective on traceability of meat products; and

(iii) Will farmers accept RFID as a solution to improve animal identification and traceability system?

1.7 Focus of the study

The environment of animal identification in KZN is dynamic. On the one hand there is no doubt that improved animal identification has a potential to deter stock theft. The introduction of RFID would deal with a potential threat of exclusion from global meat markets in the event of the outbreak of animal viral diseases. On the other hand, the introduction of RFID demands some levels of ability to understand and operate technological solutions. At the same time, RFID would bring additional production costs. The focus of the study is to analyse the acceptability of what could be regarded as “high technology solution" with cost implications into the rural areas of KZN which is often associated with high levels of illiteracy and poverty.

1.8 Expected limitations

Given the undulating terrain of the study area and the fact that settlements are sporadically scattered, finding reliable records from which to establish a credible sampling frame was a challenge. The records kept by the Dip Tank Committees in the eighteen villages that formed part of the study area, were the primary source of information. The credibility of this information depends on the willingness of livestock farmers to maintain these records. The second challenge, again relating to the set-up of the rural villages, it had been anticipated that the response rate might be low.

1.9 Thesis structure

This study is divided into the following six (6) chapters. Below is the synopsis of each chapter.

Chapter 1 introduces the subject matter and presents justification and relevance of the study. This Chapter describes the problem statement and the study area as well as set out research objectives and key questions. Lastly, the hypothesis of this study is whether or not is sophisticated technology acceptable as a mechanism for improvement of livestock production management practices and addressing food traceability problems facing emerging economies in general and rural communities in particular.

Chapter 2 discusses the phenomenon of animal identification and traceability based on empirical evidence reviewed for this study. The Chapter defines key concepts used in the study; describes the technical aspects of RFID and deals with aspects of legislation, guidelines and standards. Further, Chapter 2 shows that RFID has been adopted mainly in developed economies not only at a farm level, but to improve supply chains, guarantee food safety and gain a competitive advantage through product differentiation and consumer confidence.

Chapter 3 discusses research instruments carefully selected to conduct this study. This Chapter intelligently demonstrates how these research instruments were applied to minimise margin of error in order to enhance the quality and credibility of the study result.

Chapter 4 presents findings of the study obtained using the interviewer-administered questionnaire.

Chapter 5 presents a critical analysis of the findings. In making sense of the findings, an animal identification and traceability toolkit as well as theoretical constructs to test observations are used to analyse the impact of the current animal identification on traceability, reflects on how RFID works in other countries; focuses on the consequences of lack of RFID in South Africa; and finally conducts a statistical test to address the hypothesis of the study.

Chapter 6 provides a conclusion and recommendations of this study.

1.10 Conclusion

Chapter 1 presented the historical context of the subject matter to this study, making a case that RFID may appear as new technology whereas in fact it is quite old. A case is also made that the application of RFID is spreading to many other industries including livestock production to enhance animal identification and traceability. The objective of the study was presented as investigation into acceptability of RFID among livestock farmers in rural KZN following the plan of the Department of Agricultural and Rural Development to introduce this technology. The Chapter also presented the problem statement, research objectives and research questions thus providing a hint of the investigation methods and possible expected outcome of the study. Although some facts were used to set the scene of the study in Chapter 1, an in-depth presentation of empirical evidence and theoretical thinking is presented in Chapter 2.

Chapter 2 Literature review

2.1 Introduction

This Chapter presents different perspectives on animal identification and traceability based on existing studies. Large volumes of literature exist on this subject, most of which is based on the experiences of the first world economies. Animal identification is an ancient practice to ensure proof of ownership and prevent thievery. This practice has since evolved as technology advances. In its modern form, animal identification and traceability promise enhanced livestock production management and distribution of animal products through a complex supply chain in a most seamless and efficient manner. In contrast to its original purpose of ensuring ownership, efficient animal identification and traceability system caters for the interest of many stakeholders involved in the supply chain. Most importantly; animal identification and traceability systems guarantee transparency to customers on how food products are produced, processed, and distributed. Availability of information on products addresses issues of food quality and safety. Incorporation of traceability systems in the supply chain is driven by increasing awareness of consumers on food quality and safety. RFID had been adopted by many global economies to achieve animal identification and traceability. Emerging economies in the African continent, including South Africa, trail behind first world economies in this regard.

2.2 Background to Radiofrequency Identification

The practice of animal identification is quite ancient. It has been practiced by livestock farmers to apply random pertain of brand marks on animal bodies since 3 800 years ago (Sehularo 2010). It is suggested that, “this practice was first used to mark valuable animals like horses” to curb thievery (Bowling, Pendell et al. 2008, Moreki, Ndubo et al. 2012). However, the outbreak of animal diseases first experienced in the 14th Century through to the 17th Century such as the “rinderpest, contagious bovine pleuropneumonia, glanders, and rabies” shifted the focus from prevention of thievery to disease monitoring (Bowling, Pendell et al. 2008:p287). The awareness about safety of animal products preoccupied consumers (Bowling, Pendell et al. 2008). In the 18th Century when the animal disease outbreak persisted in Europe, requirements for farmers to demonstrate proof of origin of animals in the form of a certificate were demanded by the markets (Moreki, Ndubo et al. 2012).

In response to the demand for food safety, animal identification started to evolve. Animal identification started on individual farms, spreading to groups and organisations of farmers and eventually being embraced by nations. This ripple effect spread and created a network of nations across the globe sharing mutual concerns and interest on animal identification. As this took place, organisations interested in livestock development, animal health and animal welfare emerged as a result of this phenomenon. International advocacy groups concerned with animal health and animal welfare have since emerged. Examples of advocacy groups include the World Committee on Animal Health (OIE) and the International Committee on Animal Recording (ICAR). As nations introduced laws regulating animal identification, interested organisations developed guidelines and standards for globally acceptable animal identification practices.

Once it had been acknowledged that a system of traceability in livestock production was required, RFID was identified as an appropriate solution. The RFID was first invented to monitor military aircrafts during World War II (OECD 2008, Reddy 2011, Hogan, M et al. 2016, Charles, Nandin et al. 2017). It then spread to the field of health and the supply chain of many other industries (Ene 2013). Apart from military services, the supply chain was the first sector to integrate RFID in its business management and operations (Reddy 2011, Hogan, M et al. 2016). Today, RFID is widely used in retail shops to label products, in hospitals to track patients, equipment and pharmaceutical products and in airlines to track passengers' baggage (Sarma 2010). Although the first generation of RFID for livestock became available in the mid-1960s, it is only in the late 1970s that it has been used intensively (Eradus and Jansen 1999, Trevarthen 2007). The demand for the commercialisation of RFID started to increase and it is regarded as one of the fastest growing industries. (OECD 2008). It had been anticipated that the RFID industry would grow to $ 3 billion by 2010, and $26.23 billion in 2016 (OECD 2008).

Since the 1990s, a number of countries worldwide started to adopt animal identification and traceability systems in cattle production. However, others like France introduced national bovine identification and traceability as early as 1978 (Marguin 2010). The European Union (EU) adopted the traceability system in 1997 which started as voluntary but became mandatory in 2000 (Bowling, Pendell et al. 2008). While Australia first introduced bovine animal traceability in the 1960s through the Brucellosis and Turberculosis Eradication Campaign, she only adopted the National Livestock Identification System (NILS) in 1999 (Bowling, Pendell et al. 2008). In New Zealand animal identification and traceability system was adopted by the end of 2006 (Bowling, Pendell et al. 2008). In Namibia, the government established the Farm Assured Namibian Meat Scheme (FANMS), with a task to create the Namibian Livestock Identification and Traceability System (NamLITS) to meet the export requirements of the EU (Bowling, Pendell et al. 2008). In Botswana, the Livestock Identification and Trace-Back System (LITS) was introduced in 2001 in order to meet the requirements of the EU (Bowling, Pendell et al. 2008).

Table 2-1 below lists countries that have adopted animal identification and traceability systems since the late 1990s (Bowling, Pendell et al. 2008, United Republic of Tanzania 2010, Skaggs 2011, Meat Board of Namibia 2012, Moreki, Ndubo et al. 2012, Schroeder and Tonsor 2012).

Table 2-1: List of countries that have adopted RFID

Country	Date	Name of System
European Union	1997	Individual member state introduced respective systems
Australia	1999	National Livestock Identification System (NLIS)
Botswana	1999	Livestock Identification and Trace-Back System (LITS)
Brazil	2002	Brazilian System of Identification of Bovine and Buffalo Origin (SISBOV)
Canada	2002	Canadian Cattle Identification Agency (CCIA)
Japan	2003	The Cattle Traceability Law
Mexico	2003	National Livestock Individual Animal Identification System (SINIGA)

Country	Date	Name of System
South Korea	2004	South Korea beef traceability system
United State	2004	National Animal Identification System (NAIS)
Uruguay	2006	National Livestock Information System (SNIG)
New Zealand	2006	National Animal Identification and Tracing (NAIT)
Argentina	2007	Argentina Animal Health Information System (SGS)
Tanzania	2010	National Livestock Identification, Registration and Traceability System (NLIRTS)
Namibia	2011	Namibian Livestock Identification and Traceability System (NamLITS)

2.3 Definition and conceptual framework

This Section defines two concepts associated with animal identification. First, an effort is made to contextualise the concept of "animals". Then, animal identification is categorised into two: the "traditional animal identification" and the "conventional animal identification". A thorough definition of these two concepts is presented. The "conventional animal identification" incorporates the definition of 'traceability" and "RFID". Furthermore, different components, types and frequencies of RFID are discussed. This ensures that the reader has a clear understanding of how RFID technology is designed; implemented and functions.

2.3.1 Animals

The term "animal" is very broad and is inclusive of a wide range of wild game and domesticated animals (food producing animals and pets). The use of animals in this study is biased towards animals that are used to produce meat food products particularly for commercial purposes. A large volume of literature reviewed for this study is also biased towards animals associated with the meat industry. Such literature views animals and animal identification from the perspective of commercial livestock producers generally and consumers in particular. Animals are regarded as assets and means of production. Viewed as assets or means of production, ascertaining a sense of ownership becomes crucial.

2.3.2 Traditional methods of animal identification

Animal identification is defined as the process of "... registration of an animal individually, with a unique identifier, or collectively by its epidemiological unit or group with a unique group identifier" (Moreki, Ndubo et al. 2012:p926). Identification of animals is a tool for record keeping used in farm management including surveillance, containment, eradication and prevention of spread of diseases (Becker 2005). Globally, farmers have maintained animal identification and record keeping using various methods for many centuries. These methods include branding, ear notches and tattoos (Bowling, Pendell et al. 2008, Voulodimos, Patrikakis et al. 2010). Branding is achieved through a hot-iron or freeze branding using dry ice or liquid nitrogen (Voulodimos, Patrikakis et al. 2010).

2.3.3 Conventional methods of animal identification

Conventional methods refer to modern means conducted with information technology support. Conventional animal identification involves traceability systems. RFID is identified as the most effective traceability system.

2.3.3.1 Traceability

In production industries, traceability means that all products and ingredients applied in production, processing and distribution are able to be traced to the source (Berevoianu, Buiga et al. 2011). Traceability is the ability to trace feed, food-producing animals and substances used in the process of production as well as the entire value chain (Chang, Tseng et al. 2013). This definition concurs with the popular definition by ISO 8402 defining tractability as the "ability to trace the history, application or location of an entity by means of recorded identifications" (GS1 2008). Distribution of goods from producers to consumers takes place through a complex supply chain. It is critical therefore that products and its ingredients are traced through all stages of production, processing, and shipping until food products reach the consumer (Kernanb, Ayalewa et al. 2009). Further, traceability has the ability for forward tracking, that is "from raw material to markets", "from the farm to the table" or from "farm to fork" (Choe, Park et al. 2009, Ene 2013). It also has the ability for downward tracking, that is "from plate to source" (Ene 2013). Traceability system intends to provide information to consumers timely, actively and faithfully through the use of information technology (Bai and Li 2014).

2.3.3.2 Radiofrequency identification

RFID is defined as a tag "... that incorporates an integrated circuit, an antenna and memory that can store information. The tag interacts using electromagnetic waves, with a reader/writer that is connected to a computer that processes data from the tag and sends the data to the information system of the company" (Azuara, Tornos et al. 2012:p341). RFID incorporates the use of electromagnetic coupling in the radio frequency (RF) portion of the electromagnetic spectrum to transmit data (OECD 2008, Reddy 2011). It is a systems technology which enables two main points to interact, namely the reader and the tag (Sarma 2010). Basically, it is a system that transmits the identity, usually a serial number of an object using waves (Trevarthen 2007).

2.4 Components, Types and Operating Frequencies of RFID

The RFID is made up of three main components and comes in a number of forms and types varying in strength, size and quality. With respect to functioning, RFID is limited by the level of frequency or range. It is important therefore that technical dimensions of RFID as discussed below are well understood.

2.4.1 Components of Radiofrequency identification

RFID consists of three components; a tag, a reader and a server (Li and Liu 2011, Charles, Nandin et al. 2017). RFID is an integrated circuit that is coupled to an antenna, and covered and protected by the encapsulation. Depending on the working environment, the encapsulation provides protection against dust, extreme temperatures, moisture, heat and salt (Azuara, Tornos et al. 2012). Tags can be classified into three types, namely: active-tags, semi-passive tags, and passive tags.

A passive tag is not equipped with any form of power or batteries. This tag manipulates incoming electro-magnetic energy generated by the reader to power up an integrated circuit to transmit a response, (OECD 2008, Gastermann, Stopper et al. 2010, Maillart, Kamrani et al. 2010, Li and Liu 2011, Fazzinga, Flasca et al. 2016). As such, passive tags are of low cost, relatively poor regarding performance (Li and Liu 2011). The limited storage capacity and read-range reliability is compensated by the fact that the device is cheaper and smaller (Trevarthen 2007).

Active tags are equipped with, usually batteries (Trevarthen 2007, OECD 2008). Because of this, active tags are able to transmit data on a greater range, up to several hundred meters (Gastermann, Stopper et al. 2010, Maillart, Kamrani et al. 2010, Azuara, Tornos et al. 2012). The limitation of an active tag is that "...they are much larger than passive tags and significantly more expensive" (Azuara, Tornos et al. 2012:p347).

Readers, also called interrogators read data by sending "… a pulse of energy to the tag and listens for the tag's response. The tag detects this energy and sends back a response that contains the tag's serial number and possibly additional information" (OECD 2008:p16). Readers gather data by talking with tags over an RF channel (Reddy 2011, Fazzinga, Flasca et al. 2016). Depending on the type and strength of devices used and the operating environment, reading processes can be simple and quick or complex and time consuming. Interference in the environment can be mitigated by putting an anti-collision control to avoid confliction of messages (Reddy 2011). Hand-held scanners are battery powered, while fixed scanners are usually connected to the power supply (Sarma 2010).

A server is comprised of data capturing computer and a storage software system. A server is usually kept at a strategic location with controlled access. Only designated authority must gain access to ensure the safety and upkeep of information. Without a server, tags alone and readers would not fulfil a complete loop of traceability circle. Generally, animal identification and traceability have the potential to create massive volumes of data. As data increase exponentially, the need to migrate from "computation-centric to data-centric" arises (Chen, Yin et al. 2013). This migration is supported by the use of cloud computing method. Cloud computing is simply a way of using virtual data processing and storage server away from physical offices (Chen, Yin et al. 2013, Seco and Jimenez 2018). Data is stored and downloaded as required without actually seeing or being able to touch the server.

2.4.2 Types of RFID

Three types of tags used in animal identification include: ruminal boluses, ear tags and a glass encapsulated microchip (Bowling, Pendell et al. 2008, Voulodimos, Patrikakis et al. 2010). Ear tags are attached in the ear of the animal, microchip is inserted under the skin while the bolus is implanted in one of the first two stomachs of the ruminant (Travarthen 2007, Reddy 2011). Respective countries may adopt any of the three types of RFIDs depending on identified need. For example, in Namibia individual cattle are identified using ear tags with a registered bar code and an animal unique serial number (Bowling, Pendell et al. 2008). In Botswana rumen boluses are used. Each tag may be coded with: owner's name, personal identification number; the brand of the animal; colour of the animal and the location (Bowling, Pendell et al. 2008).

2.4.3 Operating standards and frequency bands

RFID frequencies (f_i) is denoted as follows: [$f$min, $f$max], where $f$min and $f$max represents minimum and maximum band frequencies respectively (Neganov, Plotnikov et al. 2012). The frequency is arranged in ascending order and is denoted as $f_i < f_{i+1}$ (Neganov, Plotnikov et al. 2012). The higher the frequency band the more effective the RFID tag will be. Frequency of the passive tags ranges between Low Frequency (LF) and High Frequency (HF) bands while active tags often operate in the Ultra-High Frequency (UHF) and microwave frequency bands (OECD 2008). Operating in LF-HF can easily be interfered with by the close proximity of metals and liquids (Reddy 2011).

It is the responsibility of respective of countries to establish bodies of authorities to regulate the use of RFID. However, various international authorities exist to set standards for RFID. The ICAR developed in 1995 is a set of requirements regarding (among others) the reading distance and reading speed. The International Organisation for Standardisation (ISO) has published standards for RFID on livestock (Kernanb, Ayalewa et al. 2009). Among others, these standards determine the operating frequencies: LF and HF as well as UHF and Microwave (Kernanb, Ayalewa et al. 2009). These frequencies vary in range, for example, LF ranges between 120 KHz to 140 KHz, while HF ranges between 850 MHz to 950 MHz and 2.4 GHz to 2.5 GHz (Voulodimos, Patrikakis et al. 2010, Reddy 2011). KHz is a unit of electromagnetic wave frequency which is equal 1 000 per second. In some cases, even HF tags are not sufficient. The highest operating range is the UHF and Microwave. The UHF ranges between (868 MHz to 928 MHz) while the Microwave ranges between 2.45 and 5,8 GHz) (Reddy 2011).

2.5 Regulatory framework

Regulatory framework is a requirement for animal identification and traceability system to maintain compliance and set standards. Operating within a set regulatory framework is supported globally by advocacy organisations such as the OIE, the World Trade Organisation WTO, the Food and Agriculture Organisation of the United Nations (FAOU), and Codex Alimentarius (Schroeder and Tonsor 2012).

While it is not practical to have a universally accepted law, international guidelines on animal identification and traceability systems have been developed. These are then observed through international treaties. Schroeder and Tensor, 2012, observe that OIE has 175, WTO 153 and Codex have 184 member countries affiliating to these respective international organisations. This affiliation facilitate compliance with: international guidelines on animal identification and traceability; management of livestock production; animal disease control; animal health and welfare; traceability of products; meat hygiene; and quality and safety of food products (Schroeder and Tonsor 2012).

A number of countries around the globe seeking to adopt livestock identification and traceability systems pass relevant laws regulating this function. First world economies have been proactive in this regard. Emerging economies in Southern African like Tanzania, Botswana and Namibia have introduced laws regulating animal identification and traceability systems mainly for trade (United Republic of Tanzania 2010, Meat Board of Namibia 2012, Moreki, Ndubo et al. 2012). While there is emphasis on livestock management and food safety assurance, introduction of animal traceability to reduce stock theft features significantly in developing countries (Toto 2010, United Republic of Tanzania 2010).

In South Africa, animal identification is regulated by the Animal Identification Act (Act No. 6 of 2002) (Republic of South Africa 2002). The Act makes provision for all livestock owners to register for authorised animal identification marks and apply these on their animals as prescribed by the law (Republic of South Africa 2002). The Act defines an animal identification mark as "... a mark registered in terms of section 5(2) and placed on any animal..." (Republic of South Africa 2002: p2). This Act categorically excludes other forms of animal identification, such as mark made with paint, tag attached on the ear, notch or hole (Republic of South Africa 2002). The Animal Identification Act is limited to visual animal identification which ignores electronic traceability mechanisms.

2.6 Driving factors for adoption of RFID

In recent years animal identification and traceability has been prioritised for a range of reasons. These include farm management, disease control, meeting export requirements and meeting consumer demands for food quality and safety (Moreki, Ndubo et al. 2012). Further, consumers are increasingly becoming conscious about food safety and therefore shifting towards buying food products that can be traced to source (Glynn and Schroeder 2006). Global demand for intensification of food production and the need for agriculture to contribute to economic growth means that production efficiencies and management of inventories must equally be improved (Besbes, Hoffmann et al. 2010). Distribution of food products through the supply chain exposes these inventories to theft and contamination. Increased awareness of consumers about food safety, quality, animal welfare and environmental impact of livestock production, has necessitated the provision of detailed product information to consumers (Besbes, Hoffmann et al. 2010, DOINEA, BOJA et al. 2015). Key drivers for RFID including improvement of farm management; supply chain management; marketing; commercial factors; and lastly food safety incidents are discussed in this section.

2.6.1 Improvement of farm management

In livestock production, traceability fulfils three important aspects, animal identification, premises and owner registration and lastly animal movement control (Salina and Azmie 2013). Traceability enables livestock producers to identify individual animals, manage the movement of animals and improve disease surveillance (Schulz and Tonsor 2010, Sehularo 2010). However, animal identification and traceability system is also used to prevent thievery (Besbes, Hoffmann et al. 2010, Smiley 2015).

At a farm level RFID improves efficiency and reduces costs by elimination of labour costs, reduction of error in reading data, and introduction of automation feed monitoring (Eradus and Jansen 1999, V and R 2017). Traceability is necessary for the eradication of some animal diseases, herd management and cattle trade (Marguin 2010, Sehularo 2010, Toto 2010, United Republic of Tanzania 2010). It also helps to reduce fraud, track stolen stock, help with disease surveillance and improve stock record keeping as well as herd-book administration (Staake, Michahelles et al. 2010, V and R 2017). Traceability provides farmers with an "... efficient way to identify source of and quickly solve animal production problems that affect overall value of animals throughout production and processing" (Schulz and Tonsor 2010:p659).

2.6.2 Improvement of supply chain management

In the supply chain management (SCM), the RFID is adopted for its ability to identify objects and transmitting such information using electromagnetic waves (Sobottka, Leitner et al. 2012). Its main use is to track and trace the movement of goods and products with a view to improve efficiency and certainty of delivering at the right time and place (Sarma 2010, Dangage, Radia-Melis et al. 2016). It also enables companies to determine shrinkage of products caused by theft or damage as well as estimates delivery time (Hardgrave and Miller 2010, Zimerman 2011, Anna, Ronn et al. 2017, Bibi, Guillaume et al. 2017). In this scenario, RFID is used as "… an indirect way to infer whether a product has remained within the legitimate supply chain, and to assure its pedigree"(Sarma 2010:p29).

RFID creates a link between producers and consumers through the supply chain by ensuring that there is continuity of traceability beyond the point of slaughter (Grande and Vieira 2013). During distribution, RFID enables stakeholders in the supply chain to determine the exact position, in real time, of products until delivery is made (Grande and Vieira 2013). Organisations require traceability systems that fulfils internal operations, but that are also able to communicate easily across industries domestically and internationally (van der Merwe and Kirsten 2013, Dangage, Radia-Melis et al. 2016).

2.6.3 Marketing

Traceability system serves as means to gain access to the international premium beef market (Salina and Azmie 2013). It is argued that RFID is "an increasingly important factor in current global markets characterised by high competitiveness in quality." (Azuara, Tornos et al. 2012: p341). Beef exporting countries are gradually adopting RFID to meet international standards for food safety and to increase market share (Schroeder and Tonsor 2012).

To offer customer value, measured quality assurance standards (QAS) "... have been implemented in many production environments. These systems include the use of certification marks by the producer, traceability system, third-party audits and affidavits from producers" (Azuara, Tornos et al. 2012:p341). It is argued that "QAS improve the brand image, differentiating it from competitors and enhancing consumer confidence …" (Azuara, Tornos et al. 2012:p341). Firms which are able to respond to consumer demand for information about products on offer, set themselves apart from their peers and thereby gain a competitive advantage (Chang, Tseng et al. 2013). This way, the traceability system becomes a means for market differentiation. Compliance with market standards is a strategic means to penetrate niche markets (Bowles, Paskin et al. 2005, Glynn and

Schroeder 2006). Countries such as Namibia and Botswana have managed to penetrate EU export markets through this system.

2.6.4 Food Safety Incidents and Increasing Consumer Awareness

Efforts made by livestock producers to meet the global market demand for food quality and safety has in the past 3 (three) decades suffered from various food safety incidents (Ahoya and Glaze 2009, Besbes, Hoffmann et al. 2010, Voulodimos, Patrikakis et al. 2010, Feng, Feng et al. 2013). The outbreak of the BSE in 1996 and in 2002, is one of the catastrophes that has had a huge negative impact in the beef industry (Trevarthen 2007, Besbes, Hoffmann et al. 2010, Buskirk, Schweihofer et al. 2012). The BSE outbreak in 1996 affected the beef trade in the EU and in particular exports (Velez, Sanchez et al. 2013, Hogan, M et al. 2016). This crisis resulted in a 10 year EU ban of cattle and beef exports from Britain, a decline in consumer confidence and profit margin loss (Kernanb, Ayalewa et al. 2009). Food safety concerns are key drivers for traceability, especially in well developed economies such as the EU and the US (Moreki, Ndubo et al. 2012, Rebala, Alina A et al. 2016, Omarov, Agrakov et al. 2017).

Besides the BSE, there has been a number of food accidents including: “lean meat”; “poisonous milk powder”; “Sunden red”; and “ripener” (Bai and Li 2014). The outbreak of H5N1 avian influenza in South Africa and later FMD in February 2011 raised serious concerns among consumers globally (Olivier, Fourie et al. 2006, Aung and Chang 2014, GAIN 2014). The beef industry in South Africa suffered horsemeat scandal in 2013 following mislabelling of horsemeat as beef and exporting it to 15 countries in Europe (Clark 2013). All this has made consumers to be cautious about “...what they eat, whether food is from a sustainable source, whether it is produced using eco-friendly methods, and whether the production, transportation and storage conditions guarantee food safety” (Chang, Tseng et al. 2013:p1363). Besides food safety incidents, the market uncertainty of the impact of the use of antibiotics in livestock farming to human health is a concern. It is estimated that in the US alone, antibiotic-resistant infections cause an estimated 23 000 deaths per year (Chang, Wang et al. 2014). While it is difficult to prove the threat of agricultural antibiotics beyond reasonable doubt, the perception of it being harmful has resulted in consumers desiring antibiotics free meat products (Aung and Chang 2014, Chang, Wang et al. 2014, Matindoust, Baghaei-Nejad et al. 2016). This further strengthens the argument for introduction of traceability systems in the value chain.

To deal with food safety incidents, RFID provide credible information about the origin of beef products (Besbes, Hoffmann et al. 2010, Voulodimos, Patrikakis et al. 2010, Velez, Sanchez et al. 2013). This system provides reliable information to enhance food quality and safety and allows the verification of quality at any point of the production process, processing and distribution of products (Azuara, Tornos et al. 2012, Ene 2013, Bibi, Guillaume et al. 2017, Saba 2017).

2.6.5 Economic factors

RFID has gained attention from business executives because of its potential to improve commercial activities and operations, increase profits and enhance competitive advantage (Park, Koh et al. 2010). RFID has a potential "... to transform all areas of business: manufacturing, transportation, distribution, warehousing inventory, sales, marketing, and customer services" (Park, Koh et al. 2010:p683). Businesses are able to track products, cases and pallets to support planning, decision making, SCM and customer relationship management (CRM) (Park, Koh et al. 2010). RFID allows business to manage inventory accurately, improve security against product shrinkages, improve traceable warranties and targeted product recalls, brings efficiency and reduce processing time and labour (Park, Koh et al. 2010, Badia-Melis, Mc Carthy et al. 2018). In this way, companies are able to reduce production costs and increase profit margins.

2.7 Cost-benefit analysis

The risk of food incidents is not only a threat to human health; however, lack of consumer confidence also affects the commercial health of businesses. It is observed that consumers' perception of food incidents influences purchasing behaviour (Choe, Park et al. 2009, Anna, Ronn et al. 2017). Shortly after the outbreak of the BSE, beef sales in Europe dropped significantly to 40% in France, 60% in Germany; 42% in Italy; and 30% in Portugal (Choe, Park et al. 2009). With the incident of the BSE in 2004, the export restrictions in the US caused a loss ranging between $3.2 billion to $4.7 billion in 2004 alone as a result to restriction of trade (Skaggs 2011, Schroeder and Tonsor 2012). In South Africa the outbreak of FMD in 2011 resulted in the ban of red meat export being imposed by the OIE and a R4 billion loss worth of trade (GAIN 2014). While costs of not having a traceability system are manifested mainly during animal disease outbreak, its impact can be enormous.

Benefits associated with a traceability system in dealing with safety and quality issues are numerous. The RFID monitors animal movement between locations and has the ability to trace an animal from birth until it is slaughtered at a butchery (Voulodimos, Patrikakis et al. 2010, Liang, Cao et al. 2015). Suppliers are able to prevent contaminated or low quality products reaching the consumers, increase consumer confidence and thus build brand loyalty (Choe, Park et al. 2009, Bibi, Guillaume et al. 2017). This way the commercial health and increased profits can be maintained (Choe, Park et al. 2009, Besbes, Hoffmann et al. 2010, Anna, Ronn et al. 2017). It is argued that "... profit obtained from producing traceable food is greater than the profit obtained from producing ordinary food (Bai and Li 2014:p45). This is because RFID provides an opportunity to reduce labour costs, decrease inventory shrinkage and increase sales through building consumer confidence (Kumari, Narsaiah et al. 2015, Lorite, Selkälä et al. 2017, Badia-Melis, Mc Carthy et al. 2018, Biswal, Jenamani et al. 2018).

2.8 The Cost Bearer Dilemma

Adoption of RFID is costly. Literature recognises that there is a tendency to expect a particular party in the supply chain to bear the cost of implementing the RFID. Normally farmers and abattoirs bear such costs. However, distributers; retailers; marketers; consumers and even government also enjoy the benefits of the RFID. For this reason, it is suggested that government must play a role. Government involvement could include incentives "... to the enterprises which implement the quality and safety traceability system of agricultural products ..." (Bai and Li 2014:p46). Governments can also take the responsibility of managing the behaviour of stakeholders in the supply chain through international conventions, internal regulations and monitoring (Bai and Li 2014).

The study of the Karoo sheep observed that the abattoir carried "... all the costs of the implementation of a traceability system while very little of the benefits befall them" (Kirsten, Jordaan et al. 2013:p79). A similar challenge was experienced among the resource-poor farmers in the US (Skaggs 2011). Throughout the world, resource-poor farmers, have low incomes and would battle to implement RFID on their own (Skaggs 2011, Jenjezwa and Seethal 2014). It is for this reason that the role of government in support of these farmers is advanced. The US government invested up to $120 million of public funds in 2009 to support non-commercial farmers during the introduction of a traceability system (Skaggs 2011). Also, the government of Namibia through the Meat Board of Namibia offered subsidies to support cattle farmers comply with the NamLITS (Meat Board of Namibia 2012).

2.9 Acceptance of RFID

The introduction of NAIS in the US had to deal with two critical concerns. The first was that small-scale farmers suspected the intentions of government and believed that NAIS was being used as a false emergency to extend government control (Skaggs 2011). The second was the concerns with respect to costs and benefits of the system. It appeared that non-commercial farmers would bear additional operational costs by adopting the NAIS while other participants in the value chain reaped benefits (Skaggs 2011). Scepticism among abattoir operators in South Africa is based on the idea that all participants in the supply chain will benefit from RFID even though only a few paid for its implementation (van der Merwe 2012, Kirsten, Jordaan et al. 2013).

2.10 Animal Identification and Traceability in South Africa

Given that this study took place in South Africa, attention is paid to the animal identification system in the country. The South African beef industry has suffered from the FMD outbreak and the horsemeat scandal. It is observed that the responsibilities of government to control food safety are fragmented because of "... a multiplicity of players resulting in overlaps and gaps, breakdown of the chain of command, lack of effective coordination and inefficient use of resources" (Department of Agriculture, Forestry and Fisheries 2013:p6). Further, the lack of effective traceability as manifested through the horsemeat scandal was attributed to "... involvement of multiple intermediaries across multiple countries in the supply chain of raw meat products, making it difficult to trace the ingredients used in the meat product" (Department of Agriculture, Forestry and Fisheries 2013).

The Meat Safety Act (Act No. 40 of 2000) attempts to introduce standards in animal products in order to promote meat safety (Republic of South Africa 2002). Among others, the Act is considerate of the interest of the consumers. In terms of Section 11(1)(0) of the Act, "the owner of an abattoir must keep the prescribed records relating to the number of animals slaughtered, the origin of animals slaughtered, details of examinations carried out while the animals were alive and inspections carried out after animals had been slaughtered and destinations of the meat and animal products, and must at the request of a person contemplated in paragraph (c) furnish such information to the person" (Republic of South Africa 2002: p 6). The intention of the Meat Safety Act to promote safety standards through detailed record keeping is weakened by inability of the Animal Identification Act to provide for superior means of record keeping at the farm level. How can abattoirs keep records about the origin of animals, when such records are non-existent in the first place?

The absence of a national animal traceability system in South Africa does not suggest that there is no such capacity for the application of RFID. Traceability has been adopted on an ad-hoc basis by various livestock producers and abattoirs to respond to market demands. A study conducted in the sheep industry in the Karoo showed that "... the South African sheep meat industry and its abattoirs generally have the ability to trace a meat product with their traceability systems" (Kirsten, Jordaan et al. 2013:p81).

Currently, South Africa is being monitored by the OIE in an effort to put FMD control measures in place to be fully accepted in the EU beef markets (Department of Agriculture, Forestry and Fisheries 2014). During the visit of the OIE in November 2014, the Committee appeared to have been encouraged with efforts made by the South African government authority, Veterinarian Services, to control FMD (Department of Agriculture, Forestry and Fisheries 2014).

2.11 Traceability in other commodities in South Africa

Discussion in Section 2.10 shows that the sheep industry and sheep abattoir have sufficient capacity to apply traceability in the supply chain. Given that the Animal Identification Act in South Africa does not regulate traceability, the existing capacity in the Karroo sheep industry has been built on a voluntary basis. Traceability systems for other industries involved in consumable products in South Africa appear to be well regulated. Examples are made of the wine and fruit industries.

The work to introduce traceability in the wine industry started as early as 2003 with the establishment of the Wine Traceability Working Group to refine the GS1 standards to facilitate compliance with traceability guidelines (GS1 2008). The Wine Traceability Working Group is a global organisation to which South Africa is a participant. The purpose of GS1 is to set standards for compliance with traceability to all countries supplying wine to the European Union (GS1 2008). In the study of traceability of the South African fruit export industry, importance of adoption of traceability system was highlighted (Olivier, Fourie et al. 2006). It is anticipated that exportation of fruit to the EU by South Africa can benefit from automated supply chain with respect to efficiency and effectiveness of traceability system (Olivier, Fourie et al. 2006). In particular, the traceability of agricultural products of plant origin are regulated by the Agricultural Product Standards Act [Act No. 119 of 1999] (Department of Agriculture, Forestry and Fisheries 2007).

2.12 Risks and Limitations of RFID

The promise of RFID as a technological solution to improve animal identification and traceability is not without risks and limitations. While RFID is effective in tracking the movement of goods in the supply chain, this technology is constrained by the inability to fully protect "… any information about conditions that the product has encountered through its passage along the supply chain" (Chain and Lee 2010;p61). The ability of RFID readers can be constrained by a number of factors including: poor positioning, interference from metals or other RFID tags, the distance and the ability of the reader to activate energy from the chip (Chain and Lee 2010, Min 2010, Smiley 2015).

There are also challenges with regard to retrieval of data. It is argued that readers "… are not always able to read a chip on a 100% basis" (Min 2010:p36). Effectiveness of RFID is hampered by jamming, cloning, eavesdropping, skimming and malware (OECD 2008, Costa, Antonucci et al. 2013). RFID is subject to malicious counterfeiting attacks, lack of cooperation among different parties in the supply chain, transmission interference and cost risks (Park, Koh et al. 2010, Li and Liu 2011). In Botswana some of the challenges experienced in the implementation of the LITS included the lack of political will, limited human and financial capacity and lack of coordination among different players (Moreki, Ndubo et al. 2012).

The type of technology can also pose some limitations. For example, ear-tags may break loose from the ear (Moreki, Ndubo et al. 2012). Ear-tags are also prone to tampering and adverse temperature. The bolus has an advantage that it is less prone to tampering and as such, more secure than the external ear-tag (Moreki, Ndubo et al. 2012). The disadvantage of the bolus is that it is expensive than the ear-tag.

2.13 Conclusion

Literature reviewed for this study has shown that animal identification is an old practice which started as a means to prove ownership. However, this ancient practice has since evolved to enable effective participation of beef producers in the global meat and dairy market. The phenomenon of international trading and the set acceptable standards products have to meet is no exception to the beef and dairy industry. In addition to meeting minimum production management and requirements, beef and dairy production also has to comply with international acceptable standards. Trading in the global market requires integration of production of meat and meat products into the global market through the supply chain. It also means that there has to be a sustainable network between the producer and the consumer.

The outbreak of animal diseases in the past decades has made the consumer to desire more information about how the production process takes place. In response to global consumer demand and the need to maintain access to the global market, traceability systems have been integrated into animal identification. Key drivers of RIFD include farm management, supply chain management, marketing and commercial factors inevitably imposes traceability systems into the supply chain including production, distribution and marketing. In the past decades there has been a migration towards animal identification and traceability by well developed world economies. Some countries in Southern Africa have followed suit. Surprisingly, others including South Africa seem to resist this migration for reasons that are not known.

Chapter 2 extended the discussion on the context of RFID which started in Chapter 1. Given that this Chapter provided relevant empirical evidence, Chapter 3 is concerned with setting the objectives, key questions and research methodologies. The intention is to outline the roadmap for data collecting and analysing.

Chapter 3 : Methodology

3.1 Introduction

A quantitative approach was adopted to conduct this study. Scientific research follows a rigorous design to determine appropriate instruments to collect, measure and analyse data. Research is judged on credibility, validity, reliability and the generalizability of the findings. This is achieved through minimising errors that may occur during a research exercise. This Chapter presents: research design; sampling; and data collection procedures followed in this study. The Chapter also explains and justifies how adopted research instruments contributed to the credibility, validity, reliability and generalizability to enhance the quality of study results.

3.2 Research Paradigm

There are two main paradigms for conducting research. These are quantitative and qualitative research paradigms. Both of these paradigms were considered to determine the most appropriate approach for this study. The distinction between quantitative and qualitative is with respect to sampling procedures, data collection and data measurement. The quantitative research method is predominantly positivist while the qualitative approach is predominantly phenomenological (Sekaran and Bougie 2013).

The Positivist approach works "... with an observable social reality and that the end product of such research can be the derivation of laws or law-like generalisations similar to those produced by the physical and natural scientists (Remenyi, Williams et al. 2010). On the contrary, the phenomenological approach is theoretical and assumes that '... the world can be modelled, but not necessarily in a mathematical sense. A verbal, diagrammatic, or descriptive model could be acceptable" (Remenyi, Williams et al. 2010:p34). Positivists uses statistical measurements while the phenomenological perspective relies on descriptive measurements.

3.2.1 Research Design

Research design is a "... blueprint for the collection, measurement, and analysis of data, based on the research question of the study" (Sekaran and Bougie 2013:p95). The overall research design ensures that the researcher is able to address the research problem successfully. The research design must be aligned to the research paradigm while being able to dictate the research strategy. Research design in terms of data collection, measurement, and analysis for this study is quantitative in nature, and thus differed from qualitative methods.

3.2.2 Research Strategy

Research strategy distinguishes the research type and purpose. There are a number of research strategies that may be adopted, including: explorative strategy, case study, experiments, and descriptive survey research.

Explorative strategy is qualitative in nature and is concerned with studying a relatively new subject (Fouche and de Vos 2002). It relies on collecting data through observation or unstructured or semi-structured questionnaires. Observation strategy involves watching and interpreting the attitudes and behaviour of respondents in their natural setting (Sekaran and Bougie 2013). Given that the purpose of the study was to understand the attitude and opinions of the livestock farmers towards RFID, the explorative research method could not be relevant.

In a case study a research may study a real life situation of an individual or a group by collecting in-depth data using multiple data collection methods (Sekaran and Bougie 2013). The in-depth element of the case study and the requirement for multi data collection methods excluded this method for this purpose of this study.

Experimental strategy relies on experimental designs with the aim to deduct causal relationship (Sekaran and Bougie 2013). Experimental design is usually used to compare two groups of subjects, these being an independent and the control group (Fouche and de

Vos 2002). The purpose is to test the relationship, usually, the cause and effect between the independent and control group. Again, this method was excluded for this study as there was no intention to analyse the group relationship or cause and effect factors.

Descriptive research studies on the other hand ask respondents about opinions and factual factors (Sekaran and Bougie 2013). The survey study is based on interviewing a cross-section of respondents in the field using a questionnaire or sending questionnaires by mail (Sekaran and Bougie 2013). Respondents are sampled using random methods (Fouche and de Vos 2002). Among others, the reliability and strength of the study is derived from the harmony of responses provided by a cross-section of the respondents. This method was deemed relevant for this purpose of this study as it would enable the researcher to randomly select respondents from whom to collect data using a structured questionnaire.

This study sought to establish the acceptability of RFID among livestock farmers in KZN. A survey was adopted to test their (livestock farmers) opinions and attitudes about this technology. The rural conditions under which these livestock farmers operate, dictated that a field study be conducted. As discussed in Section 3.2.3, the study area is one of the poorest areas in KZN with poorly developed infrastructure in general and telecommunication in particular. Other approaches of collecting data through mail could not have been practical, hence the field survey using structured questionnaires which were administered by field workers.

3.2.3 Research Setting

There are two generally accepted study settings, the contrived and non-contrived setting. Non-contrived setting refers to a natural and uncontrolled environment where events proceed normally while contrived setting refers to a controlled or artificial environment (Sekaran and Bougie 2013). Non-contrived and contrived studies refers to field and laboratory studies respectively (Sekaran and Bougie 2013). Analysing the setting of the study provide an insight to the nature and characteristics of the unit of analysis and so as the possible types of biasness. This study was conducted in an open environment classified as a non-contrived research setting.

The study was conducted among livestock farmers at Machunwini and abaThembu Traditional Areas at Msinga, a deep rural area in KZN. The two areas form part of the six traditional council areas within Msinga; these being Qamu, Mbomvu, Ngome and Mabaso (Msinga Municipality 2012). This area falls within a dual administration, a traditional system led by hereditary Chiefs or aMakhosi and a democratic system led by elected councillors. The area of Msinga extends over 2 500 km² and is inhabited by a total of 177 577 people (Msinga Municipality 2012). This population is comprised of 43.44% and 56.55% males and females respectively (Msinga Municipality 2012). The population of KZN is considered young with the majority aged below 35 years of age (Statistics South Africa 2011). The population of Msinga is younger compared to the provincial statistics with the majority being below 30 years of age (Statistics South Africa 2011).

The Msinga Municipality has been identified as the poorest municipality in KwaZulu-Natal and is also ranked as the poorest municipality in South Africa (Statistics South Africa 2014). In South Africa there is about 10.2 million people out of 52 million people or 20.2% of the total population living in extreme poverty (Statistics South Africa 2014). Poverty in South Africa needs to be understood in terms of the Gini coefficient, a measure of income inequality. In terms of the South African Statistics census, South Africa has a Gini coefficient of 0.69 (Statistics South Africa 2014). This means that rich people are getting richer while the poor are becoming destitute.

Livestock production is an important contributor to livelihoods. Common livestock species in the area include cattle, goats, sheep, poultry, donkeys and horses (Bayer, Alckock et al. 2003). Livestock is kept for different uses including settling lobola (gift or a dowry offered by the groom to a bride’s family as part of negotiations for arranging marriages); meat; hides for making traditional attire and for ploughing in the case of donkeys (Bayer, Alckock et al. 2003). Marketing of livestock is limited to the informal local market (Bayer, Alckock et al. 2003).

3.3 Gaining entry into the study area

Before data was collected, gaining entry into the study areas as well as dealing with gate-keeping issues were considered. The researcher visited the area to introduce the purpose of the study to farmers during one of the meetings that the Msinga Livestock Association holds on a regular basis. This meeting was held at Mthembu Traditional Council. The main purpose of this visit was to seek entry into the study area and cooperation of the farmers. During this meeting, it was explained to farmers that data would be collected by field workers who would visit farmers in their homesteads.

The second visit was aimed at contracting and training field workers on data collection. After the training, questionnaires which had been translated into isiZulu, where distributed to the field workers. This was followed by field workers randomly visiting individual farmers and completing the questionnaires. Once completed, the researcher collected all questionnaires from the field workers, and a process of capturing using the Statistical Package of the Social Sciences (SPSS) commenced. This was followed by an analysis of data and incorporating findings into report writing.

3.4 The Profile of the target population

The members of the population from which the sample of this study was selected are livestock farmers, forming part of the isiZulu speaking community in the rural area of Msinga. The farming system is open communal grazing areas. The land used as a grazing area by farmers is also used by other community members for other needs, for example collection of firewood, gathering of thatch grass, gathering of medicinal plans, and cultivation of field crops. There is thus competition for different uses on the same land.

Livestock farmers are organised around dip-tanks where they are registered members of the Dip-tank Committees. The Dip-tank Committees form the Msinga Livestock Association. A dip-tank is a facility for dipping animals for protection against diseases, some of which are tick-borne. Dip-tank Committees keep a list of all its members as well as the number of livestock units in the area. For the purpose of this study, the list of livestock farmers being members of Dip-tank Committees was useful to determine the number of livestock farmers in the study area. The study area (aBathembu and Mchunu) had 18 dip-tanks with a total number of 1 000 livestock farmers according to the Dip-tank register. The dip-tanks are located across the study area as demonstrated in the map in Figure 3-1 above.

3.5 Research Instruments

In keeping with the quantitative paradigm, a survey was conducted in the field using a structured questionnaire. The questionnaire was conducted by trained field workers. This Section discusses research instruments used for sampling, data collection and data analysis.

3.5.1 Sampling Design

Sampling design is concerned with the selection of units of analysis from a target population and from which data is collected (Cooper and Schindler 2008). The sampling process for this study included: pinpointing a target population; determining the sample frame; identifying sampling methods and determining the sample size (Cooper and Schindler 2008). The intention was to manage errors and biasness and to ensure that the selected sample "... represents the characteristics of the population it purports to represent" (Cooper and Schindler 2008:p376).

A sample, denoted by the symbol "*n"* is a subset of the total population, denoted by the symbol "*N"* (McCutcheon 2008, Shapiro 2008, Fowler 2009, Sekaran and Bougie 2013, Blair, Czaja et al. 2014). It is noted that "... the sample size (*n*) is chosen in order to reproduce, on a sample scale, some characteristics of the whole population (*N*) (McCutcheon 2008:p782). The population is the set of members or units about which inferences are made (Blair, Czaja et al. 2014). Technically, a sample is a miniature of the population (Blair, Czaja et al. 2014). Also, a sample is a "... model of reality, and not the reality itself" (McCutcheon 2008:p783).

The model or a miniature may not always resemble the reality. This is caused by inherent sampling errors, which simply measures the distance between the "model" or "miniature" from the reality. Regarding the distance between the model and reality, it is noted that "... the less it is, the more the estimates are close to reality" (McCutcheon 2008:p783). Scientific researchers aspire for a sample that represent the target population well (Blair, Czaja et al. 2014).

3.5.2 Sampling Frame

The sample frame defines the characteristics of a target population as "... people that have a chance to be selected, given the sampling approach that is chosen" (Fowler 2009:p19). Hall 2008, suggests that a sample frame is comprised of a complete list of known units of the population. This is a list of all members of the target population from which the sample is selected (Hall 2008, Remenyi, Williams et al. 2010, Blair, Czaja et al. 2014). A comprehensive list is ideal. However, it is accepted that while the list "... should contain all elements in the population, but at times these frames often do not" (Hall 2008:p790). A sample frame is therefore important as it determines the target population from which the sample is selected (Shapiro 2008, Fowler 2009).

For the purposes of this study, the sample frame defined members of the target population as:

(i) Residents of the *aMachunu and aBathembu* Traditional Council Areas;
(ii) Livestock owners who are registered members of the Msinga Livestock Association;
(iii) Livestock owners registered with the National Register of Animal Brands;
(iv) Livestock owners who keep animals within the study area;
(v) If the original owner is late, the next of kin was recognised as the owner; and
(vi) If the owner was a migrant worker, the next of kin was recognised as the owner.

From the total population of 1 000 livestock farmers according to the Dip-Tank register, the interest of this study was to select respondents befitting the above criteria.

3.5.3 Sampling Techniques

Generally, research is conducted using either probability or non-probability sampling techniques (Cooper and Schindler 2008, McCutcheon 2008, Remenyi, Williams et al. 2010, Sekaran and Bougie 2013). It is argued that "... probability (random) sampling and non-probability sampling, are typical of quantitative and qualitative research respectively (McCutcheon 2008:p783).

Probability sampling gives all population members the same chance of being selected (Fowler 2009, Sekaran and Bougie 2013). This ensures that the sample is representative of the population and as such increases statistical inferences (McCutcheon 2008, Remenyi, Williams et al. 2010, Sekaran and Bougie 2013). The advantage of the probability sample is that it "... uses probability-based statistical procedures such as confidence intervals and hypothesis tests, in drawing inferences about the population from which the sample was drawn" (Blair, Czaja et al. 2014:p95).

On the contrary, non-probability sampling does not give members of the population a known chance of being selected and is arbitrary (Cooper and Schindler 2008, Blair, Czaja et al. 2014). As such, in this approach units of analysis are "... typically selected by judgement or convenience" (Blair, Czaja et al. 2014:p90). Non-probability sampling is prone to sampling error and biases to well-known members of the population (Remenyi, Williams et al. 2010, Blair, Czaja et al. 2014).

In probabilistic sampling, researchers may choose simple, systematic or stratified random sampling (McCutcheon 2008, Remenyi, Williams et al. 2010). The most important probabilistic sample characteristic is randomness as opposed to systematic approaches (Cooper and Schindler 2008, Sekaran and Bougie 2013, Blair, Czaja et al. 2014). In simple random sampling all elements have "... an equal chance of being selected" (Remenyi, Williams et al. 2010:p193). It ensures that elements are selected from a sample frame only once and are "... independent of one another and without replacement; once a unit is selected, it has no further chance to be selected" (Fowler 2009:p24).

There are rules for calculating probability of selection where “... each population member has a $\frac{1}{N}$ chance of being selected for the sample on any given draw” (Blair, Czaja et al. 2014:p92). The formula for calculating probability is therefore:

$$\text{Probability of slection} = \frac{Sample\ size}{population\ size} = \frac{n}{N}$$

In the case of this study where N = 1000, as discussed above, the probability for any member of the population to be selected was as follows:

$$\text{Probability of slection} = \frac{1}{1000} = 0.001\ or\ 0.1\%$$

All members of the population had an equal probability of 0.1%. To ascertain fair representation, simple random sampling was adopted. This approach ensured that all elements had an equal chance, sampling error was managed and that the results would be generalizable.

3.5.4 Sample Size

This section discusses procedures followed to determine sample size. Some research assumes that 1% (one percentage point) or 5% (five percentage points) would make a sample to be representative of the population (Fowler 2009). Other research makes assumption that “... good national survey samples are generally 1 500 or that good community samples are 500” (Fowler 2009: p 43). The best scientific manner to determine the sample size as opposed to arbitrary assumptions was achieved through the application of a formula. There are different scientific formulae to calculate the sample size. This study adopted a formula suggested by McCtcheon, 2008 which is based on acceptable scientific fixed data and requires that at least “N” is known in advance. Other formulae require that standard deviation and or variance are known in advance. For the population targeted for this study, standard deviation and variance were not known in advance. The formulae adopted for this study further sets a criteria to conduct a confidence interval test whereby a “... desired size for a 90% or 95% confidence interval is often a useful method for determining what sample size is needed” (Shapiro 2008: p 782).

The sample size of this study was calculated using the following formula (McCutcheon 2008).

$$n = \frac{z^2\, pqN}{E^2\,(N-1) + z^2pq}$$

Let: *Z* refer to the confidence level of the estimate usually fixed at 1.96, corresponding to a 95% Confidence Interval. For this study 1.28, corresponding to 80% Confidence Interval, was used as Z instead of 1.96;

pq is the variance (that is unknown and then fixed at its maximum value: 0.25);

N is the size of the population, in this case 1 000; and

E is the sampling error (often ≤ 0.04).

Therefore: $$n = \frac{z^2\, pqN}{E^2\,(N-1)+z^2pq}$$

$$n = \frac{(1.28^2)(0.25\ x\ 1000)}{[(0.04^2)(1000-1)] + [(1.28^2)(0.25)}$$

$$n = \frac{(1.638)(250)}{[(0.0016)(999)] + [(1.638)(0.25)]}$$

$$n = \frac{409.5}{[1.60] + [0.409]}$$

$$n = \frac{409.5}{2.00}$$

$$n = 204$$

The sample size which was selected from 1 000 population is therefore 204. However, data was only collected from 170 respondents thus making it 83.33% response rate. The difficult terrain and vastness of the area coupled with time constraints was the reason for failing to achieve 100% response rate. A response rate of 83.33% is presumed satisfactory. The 170 respondents are members of the 18 dip-tanks scattered at abaMthembu and Mchunu Traditional Council Areas.

3.5.5 Data gathering methods

In quantitative design, a questionnaire is the most useful tool for data collection (Trobia 2008). A questionnaire can be self-administered or interviewer-administered. Advantages and disadvantages of both approaches were considered. A self-administered questionnaire relies on mail and internet services (Lavrakas 2008). The advantage of interviewer-administered questionnaire is that there is an opportunity to introduce the research topic, clarify questions and collect responses promptly (Sekaran and Bougie 2013). The disadvantage is that the interviewer may "... introduce bias by explaining questions differently to different people ..." (Sekaran and Bougie 2013:p147). In contrast, the advantage of the self-administered questionnaire is that it can cover a large geographical area, it is comparably cost effective and that they are completed at interviewees' convenience (Sekaran and Bougie 2013). The main disadvantage is that since this approach is reliant on telecommunications and mail, it is not applicable to areas where there is no telecommunication infrastructure. Self-administered questionnaire do not provide an opportunity for clarification of questions and tends to have low response rates (Sekaran and Bougie 2013).

Given the lack of telecommunication infrastructure in the study area; high levels of illiteracy and the vastness of the area, the interviewer-administered approach was adopted. To enhance the effectiveness of the questionnaire, a number of design elements were considered including the wording, length of questions and coding. Questions were worded in the simplest manner possible to avoid ambiguity. Questions were also designed to be short in order to avoid carrying more than one idea. Categorisation and coding of responses avoided overlaps in between responses.

3.6 Research Validity and Reliability

The confidence of research findings is influenced among others by quality and goodness of research instruments. This refers to the assessment whether all instruments used to collect and measure variables have enhanced the accuracy and scientific quality of the results (Sekaran and Bougie 2013). Two items are often considered to assess the goodness of measure, the validity and reliability of data gathering and measurement instruments.

3.6.1 Validity

Validity deals with the ability and effectiveness of instruments to measure variables it is designed to measure (Sekaran and Bougie 2013). The validity of research instruments is also referred to as "goodness of measure". Validity in research is important as it contributes towards the reliability of the outcome of the study.

Three types of validity are distinguished. They include content validity, criterion-related validity and construct validity. Content validity deals with how well the dimensions or sets represents the universe being tested (Sekaran and Bougie 2013). Criterion-related validity is concerned with the ability of the measure to differentiate sets into criterion it seeks to measure (Sekaran and Bougie 2013). Lastly, the construct validity deals with how well the measure produces results that fit the theories it intends to measure (Sekaran and Bougie 2013).

3.6.2 Reliability

Reliability of instruments refers to the extent to which they are able to eliminate error and biasness (Sekaran and Bougie 2013). The research instrument must be able to produce consistent results. The outcome of the study is said to be reliable when there is reduced biasness and errors have been eliminated. Key elements of reliability include stability of measure over time, when the repetition of measure produce the same results and when responses from two comparable measures are highly correlated (Sekaran and Bougie 2013)

3.7 Elimination of Bias

The quality of research findings also depends on the ability to eliminate and manage biasness. There are two main areas where biasness may occur. Biasness may occur during sampling or, selection and it is referred to as sampling bias. Biasness occurring during data collection, which researchers must also manage, is referred to as non-sampling bias.

3.7.1 Selection and Sampling Bias

During sample design for this study, it became crucial to mitigate for three inherent challenges, including: sample error; sample bias; and non-sample error. Sample error is defined as a "... random variation from the true characteristics of the population" (Fowler 2009:p13). Sampling error occurs when the sample does not reflect a population's true characteristics (Cooper and Schindler 2008, Blair, Czaja et al. 2014). It results from the fact that by chance as opposed to methodological design a "... sample can and will differ slightly from what it would look like if it perfectly mirrored the distribution of characteristics in the population" (Fowler 2009:p13).

The problem of sample bias indicates that a sample differs in character from the units or members of the population. Simply put, this means that "...in some systematic way the people responding to a survey are different from the target population as a whole" (Blair, Czaja et al. 2014:p11). Two types of sample bias are discussed. The first is coverage bias, which occurs when "... some segment of the population is improperly excluded from consideration in the sample ..." (Blair, Czaja et al. 2014:p13). The problem of coverage may cause under-coverage or over-coverage. Note that "under-coverage means that some members of the universe are neither on the frame nor represented on it. Over-coverage means that some elements on the frame are not members of the universe" (Hall 2008:p971). In brief over-coverage or under-coverage occurs when "... some population groups are given disproportionately high or low chances of selection (Blair, Czaja et al. 2014:p14).

3.7.2 Non-sampling bias

The last problem related to sampling is the non-sampling error. This type of an error occurs in the field during data collection. Non-sampling error occurs due to errors on the part of the interviewer or interviewee (Blair, Czaja et al. 2014). It includes the "... interviewer error related to the administration of the survey, response error related to the accuracy of responses as given, and coding error related to the accuracy of response as recorded" (Blair, Czaja et al. 2014:p14).

To eliminate sample errors and biases, the following steps were taken during the research design:

i. The problem of coverage was addressed through properly defining the target population prior to drawing a sample;
ii. Characteristics of the members of the population were contextualised within a sample frame to address sample error and sample biases. A sample frame is presented in Section 3.4.2 above; and
iii. Field workers were trained to equip them in managing the problems associated with non-sampling error.

3.7.3 Ethical stance and consideration

Another important aspect of conducting research is the compliance with ethical principles. Research ethics refers to a particular code of conduct ensuring that respondents participate voluntarily and that they are not exposed to physical, emotional and psychological harm or danger (Sekaran and Bougie 2013). There are various ethical considerations that need to be taken into account. For the purpose of this study, only three are discussed. These are harm, respondents' consent; and confidentiality.

Harm to respondents

As suggested above, harm to respondents may be physical or emotional (Strydom 2002). Researchers have a responsibility to protect respondents against any form of harm. Obtaining ethical clearance before embarking on research exercises guards against exposing respondents to either physical or emotional harm. For this study, ethical clearance was obtained, and is attached as Appendix A.

Respondents' consent

It is of utmost importance that respondents voluntarily consent to participate in any research exercise. Voluntary participation is based on adequate information about the purpose of the research study having been provided to potential respondents (Strydom 2002). Other principles of voluntary participation involve the opportunity for respondents to withdraw at any stage of the interview without prejudice. Section 3.3 above discussed the process of gaining entry to the study area which formed part of presenting the purpose of the study and achieving the respondent's consent.

Confidentiality

Another ethical consideration is concerned with treating sensitive and personal information in a confidential manner. Researchers have a responsibility to treat data collected from respondents with confidentiality (Strydom 2002). The manner in which collected data was used for this study was to the extent of capturing and analysing the data. During reporting, due care was taken to ensure that it would be impossible to read any passage of this study and be able to trace it back to any of the respondents.

Ethical consideration is managed in all research steps including designing the questionnaire, data collection and ensuring confidentiality during data analysis. Further, during data gathering, respondents participated voluntarily and reserved the right to withdraw at any stage of the interview.

3.8 Conclusion

Research procedures considered in this study included: positivist and phenomenologist ways of thinking, quantitative versus qualitative approach; probability versus non-probability sampling and data gathering procedures. Decisions to choose research instruments considered advantages and disadvantages and appropriateness of such instruments to this study. In the final analysis, this study adopted a quantitative approach, random sampling and a questionnaire. Based on a sample frame, sample size formulae, data was collected from 170 participants in the area of Msinga with the help of 25 field workers. All steps used in this study contributed to minimising sample error and sample biases with a view to enhance the credibility, reliability, quality and generalizability of the results. The data collected from respondents was systematically captured and is presented as findings in Chapter 4.

Chapter 4 Presentation of findings

4.1 Introduction

This Chapter presents the research findings. A detailed analysis and discussions of these findings follows in Chapter 5. Data was collected from 170 research respondents, captured and analysed using SPSS. Once captured, observations were measured on a Likert Scale. In accordance with the quantitative approach, research findings where summarised statistically. Reporting on findings focuses only on observations with significant statistical values. This Chapter is divided into the following sections:

i. Respondents’ demographic profile;
ii. Herd size of animals;
iii. Methods of animal identification;
iv. Effectiveness of current animal identification methods;
v. Acceptability of RFID; and
vi. Perceptions RFID benefits.

4.1.1 Demographic profile

This section describes the profile of respondents based on research findings. The demographic profile gives insight regarding the characteristics of respondents which may influence their behaviour and attitude towards both livestock production, animal identification and perceptions about RFID. For the purpose of the study, key characteristics of the respondents include gender, age, education and income. Also, the level of respondent’s dependants was considered to get a sense of the financial responsibilities.

4.1.1.1 Gender

Figure 4-1 shows that the gender of the livestock farmers who participated in this research is 25% to 75% females and males respectively.

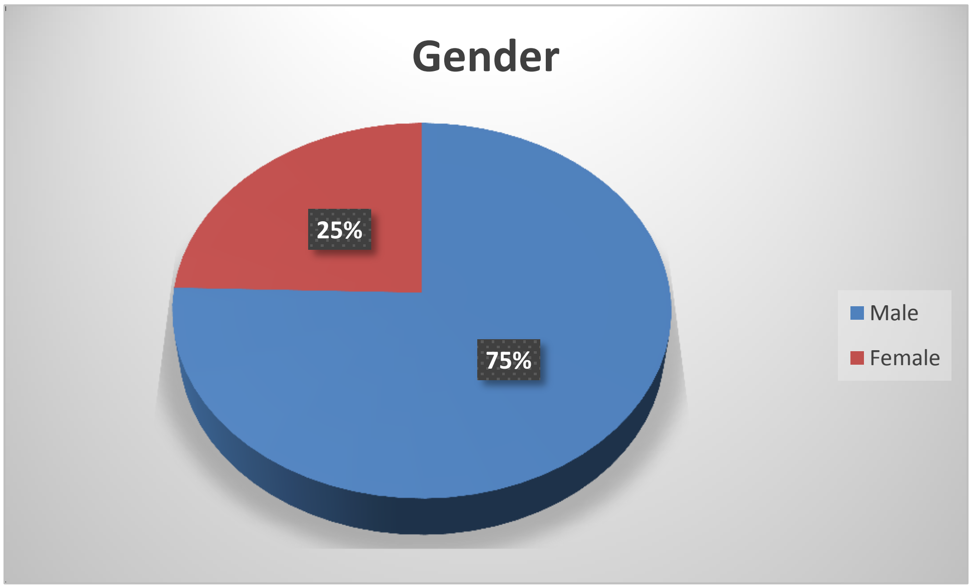

Figure 4-1: Gender of livestock farmers

The gender distribution further indicates that the ownership of livestock, which is regarded as an important means of production in Msinga, is dominated by the male livestock farmers. This finding confirms the inequality between male and female with respect to livestock ownership.

4.1.1.2 Age

The interest of the study was to establish the age distribution pattern regarding livestock ownership. The ownership of livestock based on age distribution shows that young people below the age of 40 years share a total of 19% of ownership. Livestock ownership is concentrated to the age bracket ranging from above 41 to above 61 years of age. The study found that the age bracket of 41 to 50 years owned 20%, 51 to 60 years of age owned 24%

while 60 years and above owned 36.2 %. In summary, the age distribution shows that livestock ownership is concentrated in the hands of older people as opposed to the youth.

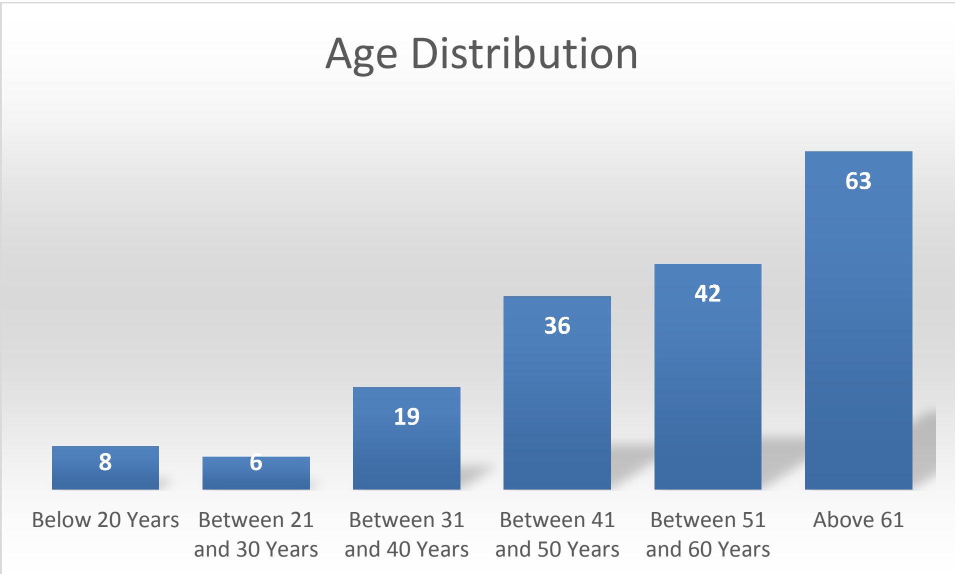

Figure 4-2: Livestock ownership by age pattern

A further step was taken to analyse ownership of livestock by gender and by age. A similar pattern is observed between the 25% female and 75% male livestock farmers in terms of ownership. Figure 4-3 below confirms that there are more males owning livestock than females. Also, the diagram shows that the distribution pattern between female and male farmers is similar to ownership and is concentrated to the older members of the population.

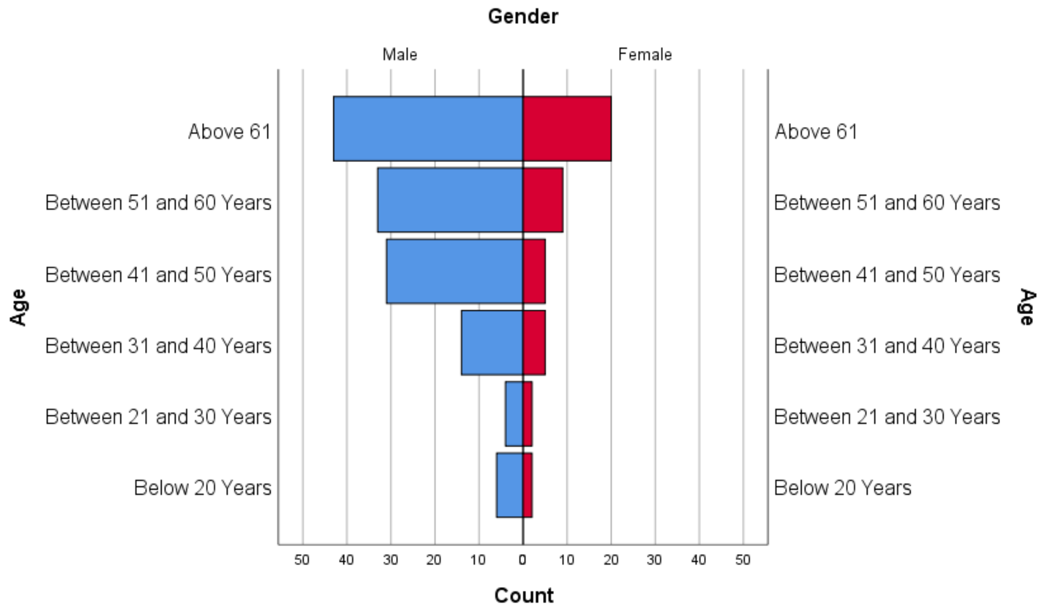

Figure 4-3: Livestock ownership by age and gender

4.1.1.3 Education and training

The assumption is that the level of education could influence the perceptions of the respondents about farming practices, and in particular their understanding of technology such as RFID. Figure 4-4 shows high levels of illiteracy among the livestock farmers at Msinga. At least 55% of respondents had no formal education whilst the level of education for at least 38% was below Grade 12. Only 4% of the respondents had reached Grade 12 while only 1% had college education.

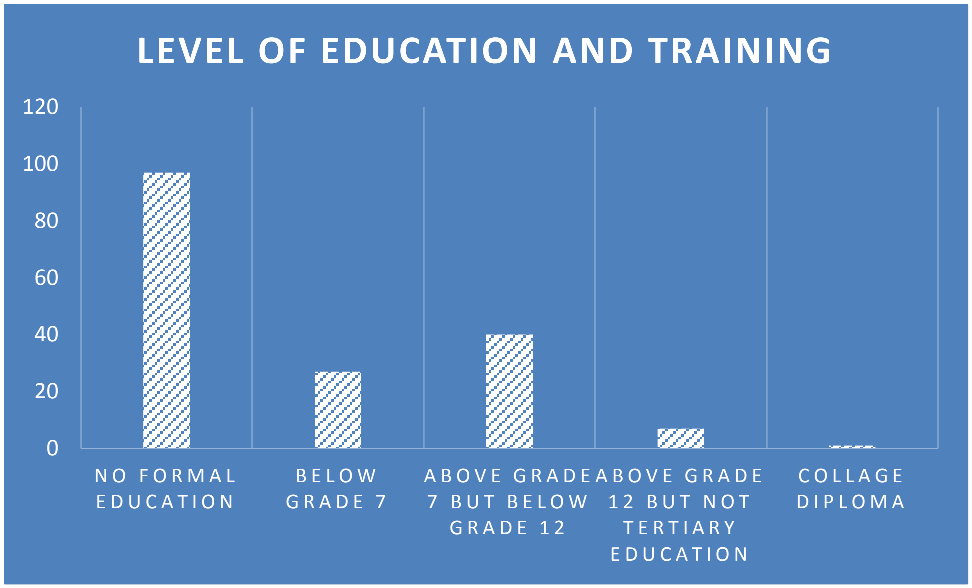

Figure 4-4: Level of education and training

4.1.1.4 Income

The question of monthly income of the respondents sought to understand two aspects. The first was to determine whether livestock farmers have had alternative sources of income or that they solely depended on livestock production for survival. Secondly, the study sought to test whether the livestock farmers had income to invest in livestock management practices such as vaccines and adoption of RFID. Figure 4-5 below shows that 48.5 % have income of less than R1000.00 per month while 42.7% earned less than R3 500.00 per month. A very small percentage of the respondents earn above R3 501.00 per month. It is observed that the livestock farmers at Msinga fall under the category of low-income earners. It may also be assumed that the 48% of the population earning less than R1000.00 might be the beneficiaries of the government social security system. However, this could not be confirmed as it did not form part of the question of this study.

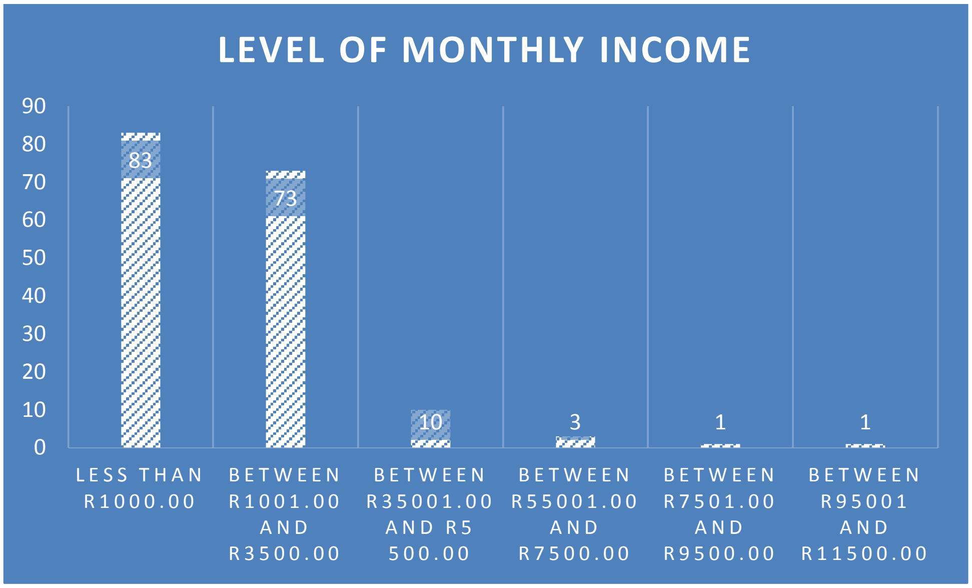

Figure 4-5: Monthly income

4.1.1.5 Dependants

Dependents are generally the members of the household that each respondent is responsible for their livelihood needs. Such needs may include clothing, food, education and health related matters. The study found that only 9% of the respondents reported that they did not have dependents. At least 23.4% had less than 4 dependents. The majority of the respondents, 34.3% and 30.9% had more than 4 but less than eight and more than eight respondents respectively. The majority of the respondents have a large number of respondents or family members to take care of. Taking into account the levels of education as well as monthly incomes, the observation is made that the respondents carry a huge burden with limited resources to meet the demand.

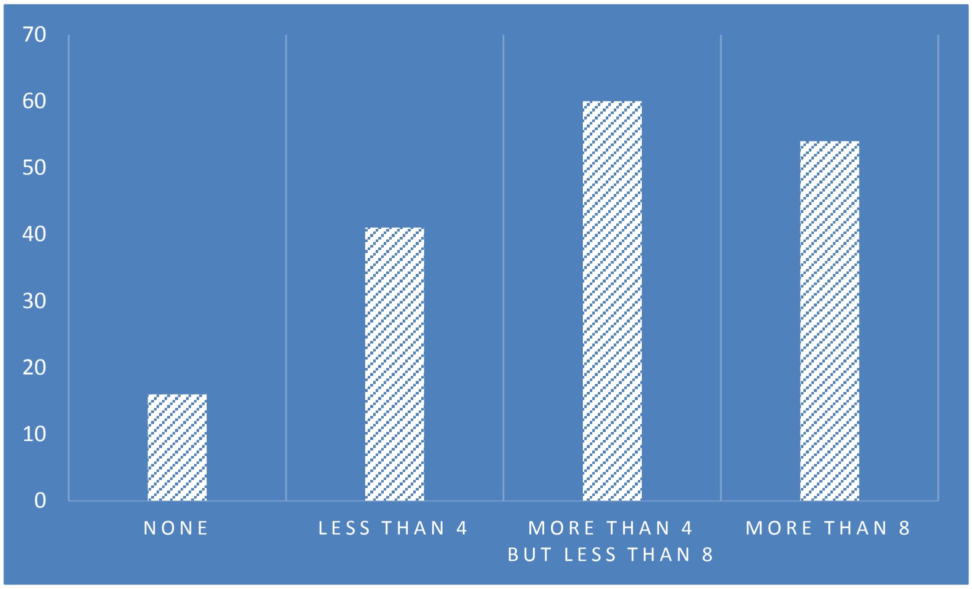

Figure 4-6: Number of dependents

4.1.2 The size of herds kept

The size of the herd kept by farmers was explored to determine the significance of livestock in the study area. The question covered different livestock including cattle, goats, sheep, horses, donkeys and pigs. Of these animals, it was found that goats, cattle and sheep are the mostly kept animals in the order of the number of farmers who keep such animals. The results of the study showed that horses, donkeys and pigs are kept by few farmers and in very small numbers compared to the first three types.

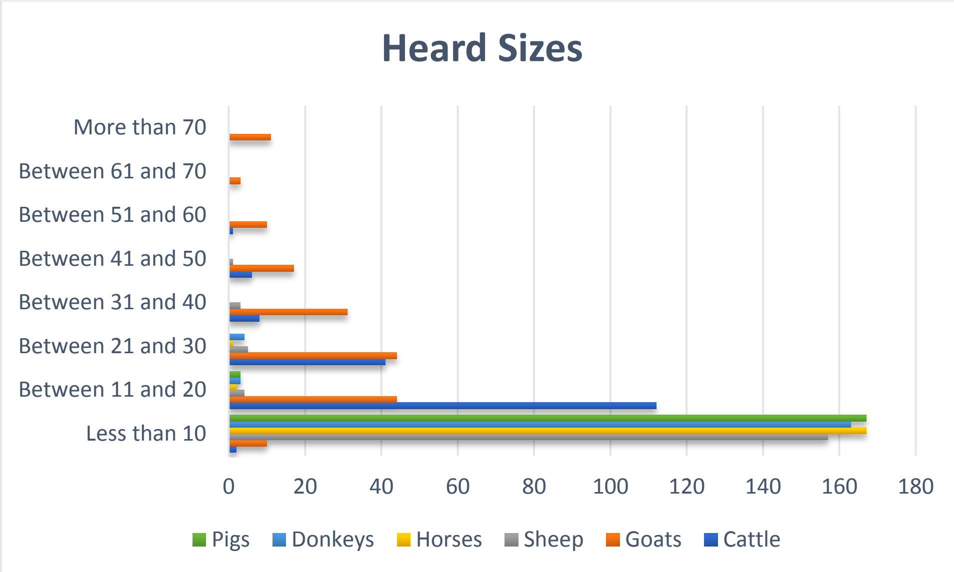

Figure 4-7 Ownership of different types of livestock

Ownership of goats ranged from 6% of farmers owning less than 10 goats; 52% owning between 11 and 50 goats; and at least 30% owning up to 60 goats. A small percentage of farmers, 5 % owned up to 70 goats.

Regarding cattle, only 1.2% of farmers own less than 10 cattle. The majority, 66% and 24% range from 11 to 20; and 21 to 30 cattle in terms of ownership respectively. Smaller percentages, 5% and 4% range from 41 to 50 and 51 to 60 in ownership of cattle respectively. Compared to goats, on average, farmers own lesser number of cattle.

With respect to sheep ownership, 92% of farmers own less than 10 sheep. The rest of farmers, which is in the minority, own between 11 and 20 sheep. Compared to goats and cattle, there were fewer livestock farmers keeping sheep.

The ownership of horses, donkeys and pigs was limited to very few farmers. It was found that 98% of farmers owned less than 10 horses; 96.4% owned less than 10 donkeys and 98% owned less than 10 pigs. Based on the findings of the study, an assumption is made that the most commonly kept animals are cattle, goats and sheep than they do on horses, donkeys and pigs. It is further assumed that these animals are more valuable with respect to contributing to livelihoods.

4.1.3 Methods of Animal identification

The interest of the study was to first establish the current animal identification by livestock farmers even before testing whether RFID would be accepted. Different methods of animal identification were tested. These include: naming animals, identification of animals by skin colour, using unauthorised brand marks, using authorised brand marks as well as combining different methods of animal identification. Figure 4.8 below presents the finding of the study on the question of animal identification.

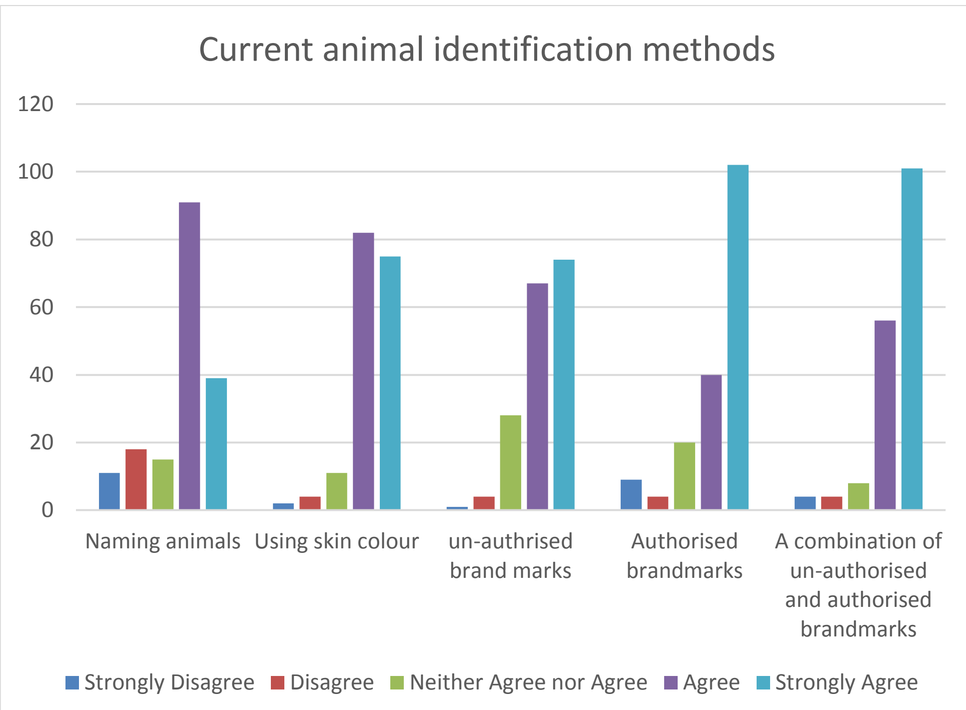

Figure 4-8 Distribution of different methods of animal identification

i. **Identification by naming animals:** The study found that at least 74.3% of the respondents identified animals by giving them names. A total of 17% did not agree with the practice of naming animals while at least 9% neither agreed nor agreed with this practice.

ii. **Identification of animals by skin colour:** The study findings showed that another form of animal identification was the use of skin colour. The majority of respondents indicated that they used the colour of the skin to identify their animals. A total of 46.9% agreed with this method of identification while 42.9% strongly agreed with this method. Only 10.3% of respondents did not agree with the use of this method of animal.

iii. **Animal identification using un-authorised brand marks:** A total of 81% agreed with the sentiment that livestock farmers use un-authorised brand marks to identify their animals. This percentage constitute 38.5% of respondents who agreed with this sentiment and the 42.5% who strongly agreed. Only 3% of the respondents did not agree that un-authorised brand marks are used to identify animals.

iv. **Animal identification using authorised brand marks:** Respondents who indicated that livestock farmers identify animals using authorised brand marks were 81% while those that responded otherwise were 7.4%. There was 11.4% who were neutral towards this question.

v. **Animal identification using the combination of un-authorised and authorised brand marks:** The study also tested the use of a combination of both un-authorised and authorised identification methods. It was found that 90% of the respondents responded that livestock farmers use both un-authorised and authorised animal identification methods, with 5% disagreeing with this approach and another 5% being neutral towards the question.

There are several practices of animal identification currently being applied by farmers in the study area. The findings of the study show that livestock farmers do not rely on a single method for animal identification but a combination of multiple methods. In legislation, there is only one recognised animal identification method, that is, the authorised animal identification issued by the relevant authority, Animal Registrar. Other animal identification methods, in particular the un-authorised brand marks, are randomly developed by livestock farmers as desperate means to enhance a sense of ownership.

4.1.4 Effectiveness of current animal identification methods (branding methods)

The study sought to establish the perception of livestock farmers regarding the effectiveness of the current animal identification methods, in particular branding methods. The idea was to test whether the current animal identification is effective with respect to keeping animal records, whether the current methods support traceability and whether animal records could be readily available on request. Figure 4.9 presents the finds of the study regarding effectiveness of the current animal identification methods.

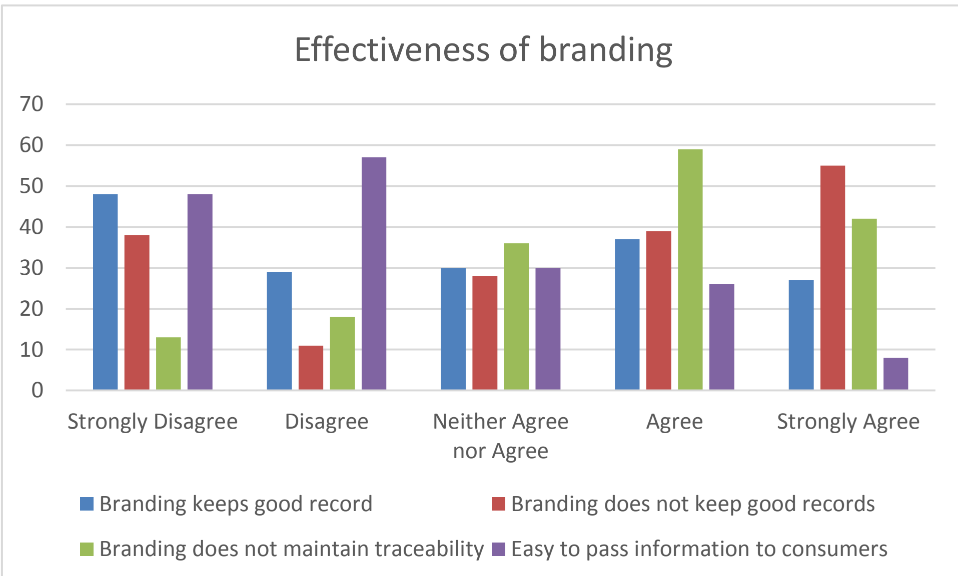

Figure 4-9: Effectiveness of current animal identification methods

The findings of the study with respect to the effectiveness of the current animal identification methods are summarised as follows:

i. **Branding keeps good records:** At least 60% of the respondents disagreed with this sentiment while only 17% believed that branding assists farmers in keeping good records.

ii. **Branding does not keep good records:** 55% of the respondents agreed that branding does not keep good records while 28% disagreed with this sentiment.

iii. **Branding does not maintain traceability:** At most 60% of the respondents agreed that branding is not capable of maintaining traceability while 18.5% thought that it does with 21% feeling neutral about the question.

iv. **Branding makes it easy to pass information to the consumers:** 20% of the respondents believed that branding allows for easy transfer of information about animal products to customers while 60% did not think that this was possible.

A number of different questions were asked in both passive and active form to test the effectiveness of the current animal branding system. In summary, it was found that the current animal branding is not effective to keep animal records and does not support traceability.

4.1.5 Acceptability of RFID

The study tested whether respondents thought that farmers in the area will accept RFID as a tool to enhance a sense of ownership. Data was collected to reflect an indication of the number of farmers that (i) will not accept RFID; and those that thought (ii) farmers will accept RFID. Figure 4-10 below presents the findings to this question.

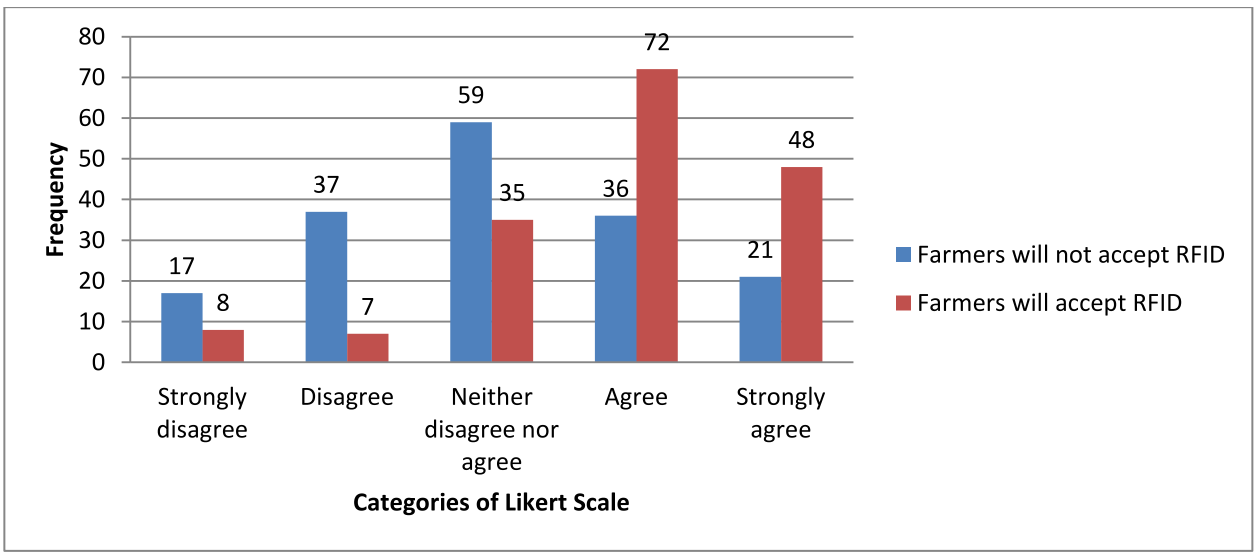

Figure 4-10: Acceptability of RFID

At most, 71% of respondents thought that farmers will accept RFID. Of these, 42.35% agreed while 28.23% strongly agreed with this sentiment. Only 32% of respondents thought that this technology will not be acceptable.

4.1.6 Perceived benefits of RFID

The study sought to understand the reasons for both acceptability of RFID or lack thereof. Four different types of benefits were considered. They include enhancement of consumer confidence, improvement of animal records, disease surveillance and improvement of breeding and selection. Figure 4.11 below presents the responses.

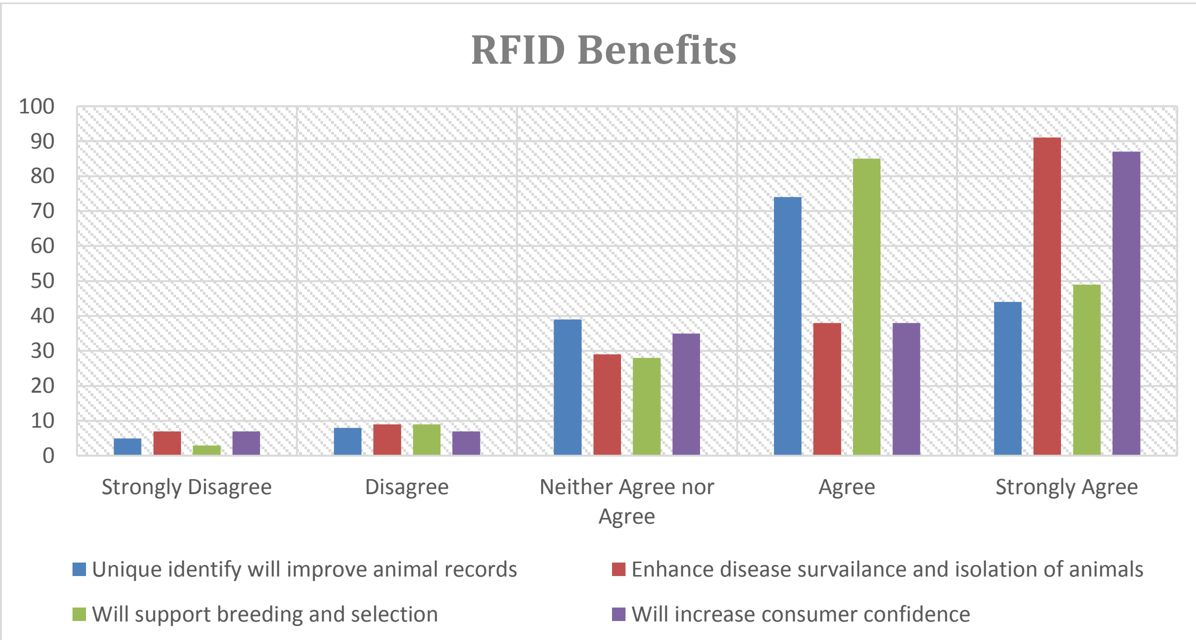

Figure 4-11: Perceptions about why RFID will be acceptable

The perceived benefits of RFID can be summarised as follows:

i. **Enhancement of consumer confidence:** The majority of respondents, 71.8%, thought that improved animal traceability will help build consumer confidence. This constitutes 21.8% of respondents who agreed and 50% of respondents who strongly agreed with this sentiment. Only 8% did not while 20.1% the respondents were neutral.

ii. **Improvement of animal records:** The majority of respondents, 69% believed that RFID will improve the upkeep of animal records while only 7.6% believed otherwise, with 22.8% being neutral towards the question.

iii. **Disease surveillance:** At most, 74% of respondents believed that RFID will improve monitoring of animal health and disease surveillance, 9.2% did not think so while 16.7% were neutral.

iv. **Support breeding and selection:** With respect to animal breeding and selection, 77% of the respondents believed that RFID will have positive benefits while 6.9% did not perceive this benefit and 16% remaining neutral to this sentiment.

In summary, the respondents believed that RFID will improve animal identification to support both production management practices as well as increased consumer confidence.

4.2 Conclusion

In conclusion, the following aspects are highlighted. Livestock production has the potential to contribute to livelihoods and alleviate poverty caused by high unemployment and low monthly income. As a result, securing a sense of ownership of animals through different methods of animal identification is important to farmers. Animal identification in the study area is applied through a dual approach of authorised and unauthorised systems. The dual approach is seen as a way of strengthening a sense of ownership. None of these two systems are fully effective with regard to the traceability of animals and animal products. The Animal Identification Act (Act No. 6 of 2002) does not have provision for traceability and as such, is also not useful in this regard. To change this situation, it is clear that RFID can play a significant role. Among others, respondents were of perceptions that RFID could improve livestock production and management, improve traceability of products and thus help build consumer confidence. It is understood that costs could become a bearer on the implementation of RFID but nevertheless, the majority of respondents believed that farmers would accept this new technology. The findings presented in Chapter 4 paves the way for an in-depth analysis and discussions in Chapter 5 to respond to the objective of the study.

Chapter 5 Discussion

5.1 Introduction

This Chapter interprets the study findings to make sense of the current animal identification practices at Msinga. The interpretation is based on both the current animal identification system in South Africa and global practices. To test whether RFID will be acceptable as an information technology solution to enhance animal identification and traceability, this Chapter constructs a theoretical framework as a measure of this inference. Chapter 6 relies on this theoretical construct to make inference and recommendations. This Chapter also reflects on the three objectives of this study as presented in Chapter 1, that is: understanding the current animal identification and traceability systems among communal farmers; effectiveness of the current animal identification on traceability of meat products; and testing farmers' willingness to accept RFID as a solution to improve the animal identification and traceability system. Lastly, this Chapter applies Chi-Square to test the hypothesis of this study, "Ho" and "H_1".

5.2 Theoretical Constructs for Animal Identification and Traceability System

One of the outcomes of a positivist research, is the derivation of "law-like" generalisations, or some theoretical constructs to measure observations (Remenyi, Williams et al. 2010). This section achieves this by developing theoretical constructs, an animal identification toolkit, redefining environments within which RFID operations and lastly, redefining a philosophy of "farm-to-fork" and "fork-to-farm".

Radiofrequency identification is based on information technology with at least two important dimensions. The first dimension of RFID is visual and tangible, while the second is neither tangible nor always visual. The RFID infrastructure such as an ear-tag and scanners form part of the tangible dimension and therefore can both be seen and touched. The software system of the RIFD such as the server form part of the intangible dimension and therefore can neither be seen nor touched. This is because in as much as a data sever is materialistic, it can also take the form of cloud computing. In this case, data is saved in a "cloud" and can only be accessed and downloaded on to users' computers or devices only when required.

Based on the literature review and data analysis three theoretical constructs are suggested. These theoretical constructs are: the understanding of RFID enablers; environmental dimensions and the "Farm-to-Fork" and "Fork-to-Farm" concept. Because RFID is by its nature a complex technology, there is a need to develop some measures to determine the existence and effectiveness of this system. Without any objective measure, the effort to understand the existence and effectiveness of traceability system remains difficult. These theoretical constructs therefore serve to form the basis for measuring the existence and effectiveness of RFID.

5.2.1 Enablers of Radiofrequency Identification

In Chapter 2, reference was made to a number of factors prompting the need for RFID. These factors also make assumptions that particular conditions must be in place justifying the need for RFID. There are also particular requirements to be met for this technology to be functional and effective, otherwise referred to in this study as RFID enablers. It is recognised that a list of such enablers can be infinite. For the purpose of this study, six important RFID enablers were identified. They are:

i. Demand or motivation for RFID technology;
ii. Guidelines, standards and legislation;
iii. Availability, acceptance and affordability of the technology;
iv. Availability of RFID technical information;
v. Cooperation of key players in the supply chain; and
vi. Proper design and implementation of RFID.

5.2.1.1 Demand and Motivation for Radiofrequency Enablers

Chapter 2 discussed and presented evidence for demand and motivational factors for RFID. These factors are categorised into two, pull and push factors. Pull factors stem from the market and serve as an incentive for producers to adhere to requirements for traceability and food quality standards. Chapter 2 also demonstrated that good response to pull and push factors triggers are compensated through profits and competitive advantage. Conversely, non-response to pull and push factors also attracts a particular outcome. The poor response and low uptake of RFID create a barrier to international premium beef markets.

Pull factors can be divided into three: consumer demand, product differentiation and requirements for supply chain efficiencies. All these three can be defined in one universal language well understood by the global corporate world; that is, increased market shares through product differentiation, increased profits margins and competitive advantage. Consumers are an incredibly influential stakeholder at the market, especially as they increasingly become aware of food incidents resulting from animal diseases as well as contamination during production and distribution of products. Due to increasing awareness, consumers continue to demand assurance on food quality and safety. The best way to provide this assurance is through traceability. There is sufficient evidence presented in Chapter 2 suggesting that many countries and particularly in first world economies, have responded to the pull factor and adopted traceability systems to guarantee food safety to customers. Once a piece of meat is on a plate at a “dinner table” hundreds if not thousands of kilometres from the place of origin, customers want to be satisfied that should a need arise, the product must be easily tracked from “plate to farm”. Existing literature has demonstrated that adoption of traceability is associated with economic gains. This is simply because guaranteed traceability of products is a way of gaining access to international markets and attracting premium prices in return for safe food. Also, pull factors are associated with improvement of supply chain efficiencies. Traceability of products through supply chain means that companies are able to manage inventories in transit by determining the exact location on real time basis. This way planning, decision making and guaranteeing delivery dates are made easy. Also, management of inventory in transit reduces labour time; controls inventory shrinkages and assists to detect contamination of food and improve call-back turn-around time. Efficiencies in supply chain management reduce operational costs and contribute to financial gains.

In contrast, push factors do not occur at the market, but at the point of origin. Like pull factors, push factors also require producers to operate in a particular manner. Different push factors may include animal disease outbreak, stock-theft and the need to improve the breed through breeding and selection.

Animal disease outbreaks are regarded as push factors, compelling producers to consider new management approaches. Countries that have been affected by animal disease outbreaks and as a result have been banned to export meat products to international markets, have adopted RFID as a production management tool. RFID has been adopted in these cases for its ability to isolate affected animals, putting in place future animal disease surveillance and effecting traceability. In terms of empirical evidence discussed in Chapter 2, South Africa has suffered from a number of animal disease outbreaks.

In the case of Msinga, the respondents highlighted stock-theft as one of the reason why RFID is required. There was also indication that RFID could enhance the management of breeding and selection. These are the factors at a production level that forces the farmers to improve traceability through technology such as RFID.

5.2.1.2 Guidelines, Quality Standards and Legislation

There are a number of international guidelines available to provide support towards the implementation of RIFD. Without such guidelines, individual countries would more than likely implement RFID based on domestically oriented frameworks which would not be compatible at a global level. There would be a mismatch of technology and it would not achieve any purpose. It is important therefore that there is as close to universal as possible set of guidelines and frameworks for implementation of RIFD.

There are sufficient guidelines for the implementation of RFID developed by well recognised international organisations with interest on product quality and safety during livestock production. Existing guidelines can be viewed from two dimensions, some pertaining to animal identification and traceability and others to RFID technology standards. As discussed in Chapter 2, guidelines pertaining to animal identification and traceability have been produced by OIE, ICAR, WTO and FAO while guidelines pertaining to technology have been developed by ISO with an intention to set acceptable standards.

In addition to international guidelines and quality standards, respective countries embarking on the implementation of RFID tend to pass relevant legislation to support this. Such legislative framework clarifies roles and responsibilities of different stakeholders. Legislation also clarifies as to whether RFID is treated as a voluntary or mandatory practice. Lastly and perhaps most importantly, a legislative framework also addresses the approach for implementation. Most countries have dealt with this concern by establishing a designated authority to become a custodian of RFID, its implementation as well as dealing with storage and use of data.

5.2.1.3 Designated Authority

Countries that have adopted RFID have done so under the auspices of an established designated authority. Such an authority becomes responsible for the design and implementation of the technology. One of the risky areas of the traceability system is ensuring that data is secured. This also becomes an important function of a designated authority. In the case of the current animal identification system in South Africa, there exists the Registrar of Animal Brands. Currently, this authority deals with animal identification using brand marks and not RFID. Custodianship of the traceability function could reasonably be an added function to this body.

5.2.1.4 Availability and Affordability of RFID

Chapter 2 demonstrated that RFID has been in existence for decades. Over this period, this technology has been improved and perfected alongside the advancement of information technology in general. RFID is also available in different types geared for different purposes. This provides options for selecting the most appropriate technology to suit the need. Availability of RFID in different types provide options to countries planning to adopt this technology.

While the availability of RFID is not a limiting factor, costs may be. Literature in Chapter 2 suggested that implementation costs may be a limiting factor. Chapter 2 also demonstrated that the consensus regarding who should bear the cost is not easily reached. This is due to the fact that benefits of this technology are shared by all stakeholders in the supply chain. Various ways of dealing with implementation costs have been discussed thoroughly in Chapter 2. This dimension is also discussed in Chapter 6. It is suggested that a solution to cost as a bearer to the implementation of RFID can be found.

The study found that the livestock farmers at Msinga are low-income earners living in an area regarded as one of the poorest municipalities in South Africa. Clearly, affordability of implementing and maintaining the RFID does not exist. Also, the study found that there was a high level of illiteracy among the livestock farmers. By its nature, the utilisation of RFID requires technical expertise. Livestock farmers at Msinga would rely on a third party, mostly likely government for subsidies and technical support for effective implementation and use of RFID.

5.2.1.5 Cooperation of Key Players in the Supply Chain

Effective implementation of RFID relies on cooperation of all role players in the supply chain. In the case of livestock, these include suppliers of feed, suppliers of medicines and vaccines, livestock producers, abattoirs, distributors, marketing agents and retail shops. All these stakeholders need to design their systems in a manner that it is compatible to each other thus forming an integrated network of the supply chain. This also ensures that stakeholders are able to interconnect and interact with one another to serve mutual interests and needs. Further, the need for compatible technology ensures that information is transferred from one stakeholder to another with ease. For example, from livestock producers to abattoirs. Disintegrated technology would mean that transfer of data is disrupted.

The stakeholders that Msinga livestock would require cooperation from include the suppliers of feed and medicines on the one hand, and the markets on the other. Providers of extension service and training, which would include government and the private sector presents another area that requires stakeholder cooperation.

5.2.1.6 Proper Design and Implementation of RFID

Once a potential user or country has decided to adopt RFID, the next most important stage is design. This stage ensures that the user is able to identify suitable technology based on interest and needs. This will also take into account existing guidelines, quality standards and legislation as well as the type of technology already incorporated into the supply chain. Also, it is important to consider advantages and disadvantages of different RFIDs in order to identify a superior, cost effective and is most effective type. The other important factor during the design stage is to plan for all important three dimensions of RFID, that is ear-tags, responders and data server. Planning for one out of three, or even two out three would merely be a waste of effort, time and resources. It is strongly suggested therefore that implementation of RFID should not be commissioned if anyone of the three dimensions is not in place.

5.2.1.7 Overview of a Checklist of Radiofrequency Identification Enablers

Based on the 6 (six) enabling factors discussed above, this study developed a toolkit that can be used to determine two factors. The first is to determine whether conditions are favourable for the implementation of RFID. Secondly, once enabling factors have been satisfied, the toolkit can be used to test necessary conditions for RFID to be effective. This toolkit is represented in Table 5-1 below. The toolkit was applied to the situation of Msinga in particular and South Africa in general to test whether conditions are favourable for adoption of RFID based on the observations during the study. Enablers for RFID were first listed and corresponding indicators were identified to determine the status of each in relation to South Africa. The application of the toolkit based on literature review and research findings suggests that some enablers to support RFID are already in place even in the case of South Africa. Others are not, but can be addressed. For example, given the situation of FMD the demand for RFID exists. Also, international guidelines and RFID technology already exist. The application of this toolkit shows that two critical enablers for

RFID, domestic legislation and a designated authority do not seem to exist. There are two other elements which are non-existent; the level of affordability and cooperation of stakeholders. However, these can easily be overcome. In particular, the availability of funds and stakeholder cooperation can be addressed through legislation and existence of a designated authority.

Table 5-1: Checklist for RFID conditions

Condition	Indicators
Demand for RFID	In the case of South Africa, both "push and pull" factors places compelling demands domestically and internationally.
Guidelines and Legislation	Internationally, there are sufficient guidelines and standards. This study could not find evidence suggesting that South Africa has necessary legislation to support livestock identification and traceability.
RFID availability and affordability	Advanced technology is available in South Africa. However, resource-poor farmers such as at Msinga may not afford, but this condition could be met through government support.
Designated Authority	This study could not find any evidence suggesting that South Africa has a designated authority responsible for livestock identification and the traceability system.
RFID design	Countries that have adopted RFID invested time and resources designing a programme of traceability.
Cooperation of stakeholders	There would not be proper stakeholder cooperation unless there is a legislative framework for such. However, stakeholder cooperation could be negotiated with success.

Based on the toolkit, it is concluded that in spite of the demand and benefits of RFID, livestock identification and traceability key enablers at Msinga and South Africa as whole generally do not exist.

5.2.2 Environmental Influences on Animal Production and Identification

Animal identification is influenced by three levels of environmental factors. When dissected, it becomes apparent that animal production and animal identification is influenced by local, national and global environmental factors. Figure 5-1 below depicts influences of environmental factors to animal production and animal identification. The discussion below demonstrates the impact of these environmental factors and possible measures that farmers can put in place.

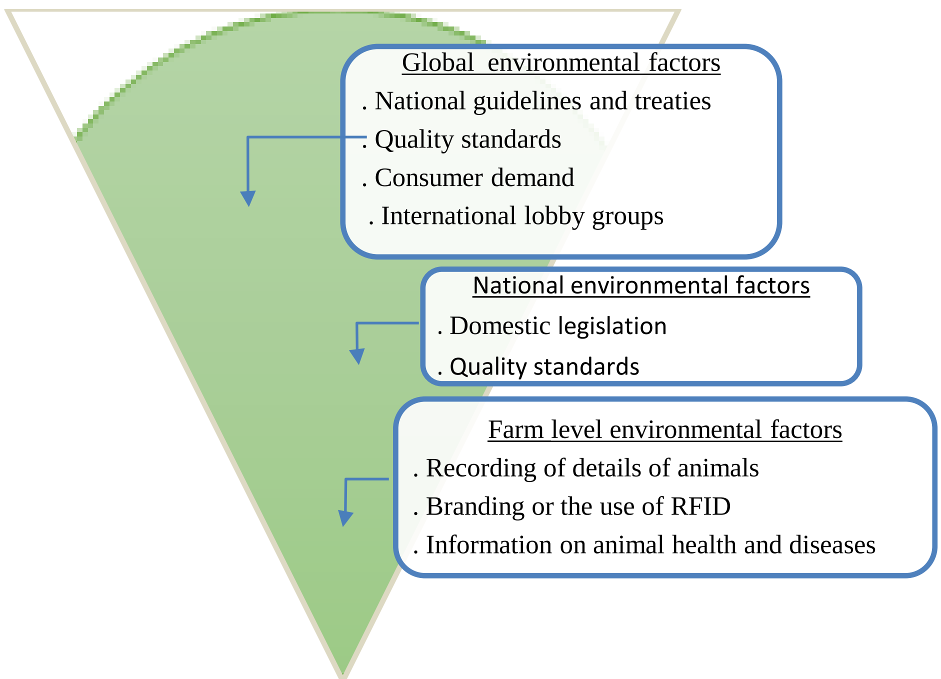

Figure 5-1: Animal identification environmental influences

Local environmental factors include farmers' responsibility to keep records of animals as part of production management. Animal records kept are with respect to feeding, animal health, disease surveillance, treatment of diseases, records of animals born on farm or bought from other farms as well as records relating to medication and vaccinations. Central to keeping all necessary animal records is proper for animal identification. Traceability can enhance animal records, data storage and retrieval. The main purpose of keeping animal records is to ensure food quality and safety. The process of keeping records also involves recording of all inputs and ingredients used during production including information of their sources. The local environment is narrow in scope and impact and as such, it is relatively manageable and easy to manipulate.

National environment refers to factors that do not only affect an individual farmer but a large number of farmers in the beef industry as a whole. This environment is intermediate but broader in scope compared to the local environment. It includes domestic legislation on matters relating to animal production and identification. Apart from legislation, there are market and supply chain requirements to be complied with. Domestic customers, especially the high-income earners and the health-conscious market, tend to exert a demand regarding food quality and safety. Because the national environment is broader than the local environment, an individual farmer is limited in terms of dealing with and managing prevailing influences. Rather, the formation of farmers into groups or even organisations representing the beef industry becomes effective in responding to these environmental influences.

Lastly, the global environment has a much wider scope affecting the beef industry across nations. At this level, national guidelines and treaties are influential on animal production and animal identification. National guidelines on animal identification are not as impactful as domestic legislation because they are voluntary. What is more impactful with respect to the global environment is the power of the consumers. Globally, consumers demand assurance of quality and food safety. The migration into the traceability system is nothing but a response by beef producing countries towards customer demands.

Livestock producers as well as other stakeholders in the supply chain need a strategy to manage the impact and influences of environmental factors on a continuous basis. Awareness of current trends in the global environment would assist with the formulation of such a strategy. Equally, being oblivious of national and global imperatives could spell disaster for individual farmers and the beef industry.

5.2.3 The “Farm to Fork” and “Fork to Farm” Philosophy

The “Farm-to-Fork” and “Fork-to-Farm” philosophy also referred to as forward tracking and downward tracking was discussed extensively in Chapter 2. This philosophy assumes that as products are distributed from farm to consumers, details concerning animal identification, production, processing and distribution is captured and transferred from one stage of the supply chain to the next. The transfer of information from one stage of the supply chain to another is accumulative. This is because as the product moves from one stage of the supply chain to the next, information originated in each phase is incorporated into the product or batch labelling. If all stakeholders keep good records of production or processing, then traceability will be achieved and so will checks and balances be maintained to ensure food quality and safety. Further, maintenance of production information as well as the ability to transfer this information from one stage of the supply chain to the next means that products can be traced from “farm-to-fork” and *vice versa.*

The information flow process through the supply chain is made complex by the fact that there are numerous stakeholders involved and whose full cooperation is required. Figure 5-2 depicts the information distribution flow from the point of origin (the farm) to the consumer. The diagram uses colour codes to distinguish between different stages. Also, colour coded multiple arrows have been incorporated to indicate the level of information that is added to original data at each stage.

It must be noted that a linear process approach has been adopted to design the diagram to demonstrate the “farm-to-fork” concept in the most simplistic manner possible. It is well understood that in real life situations, “farm-to-fork” and “fork-to-farm” are not necessarily a linear process. It is a complex process of horizontally and vertically integrated networks of information on food, food-producing animals, substances used in production, processing and distribution of food products (Chang, Tseng et al. 2013). For example, a farm has a number of suppliers and suppliers’ suppliers, all of whose farm input information needs to be recorded. The abattoir, warehouse, distributors and retailers also have suppliers and supplier’s suppliers whose inputs may affect or come into contact with animal products and as such, also needs to be recorded.

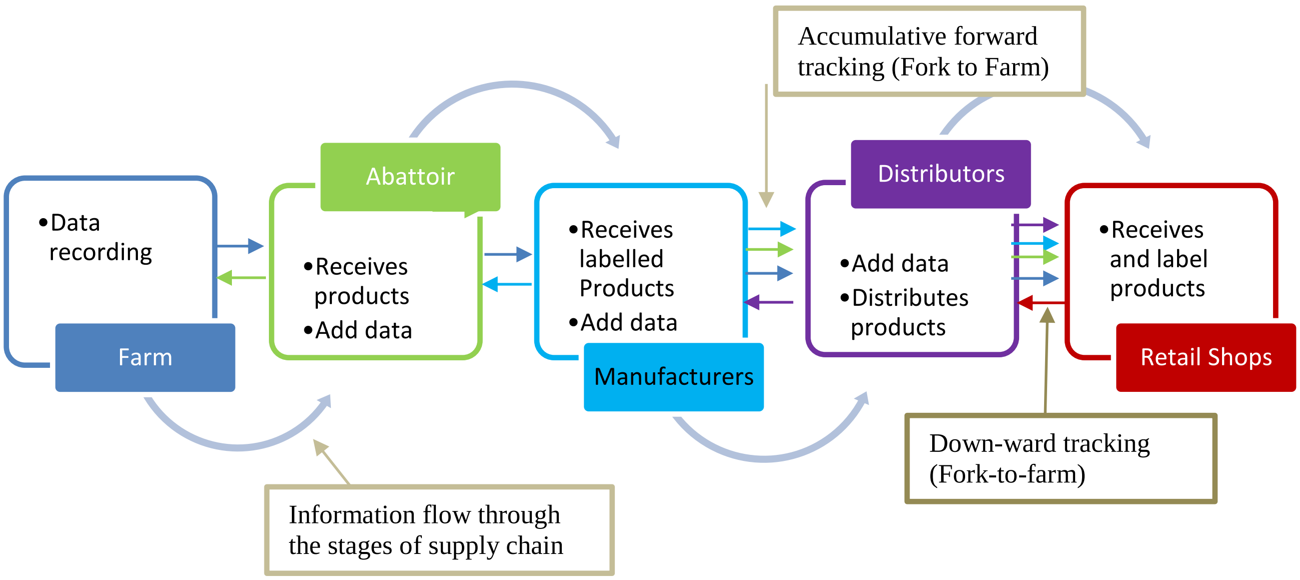

Figure 5-2: Distribution of animal products from farm to retailer

The philosophy of "farm-to-fork" and "fork-to-farm" basically implies a link between producers and consumers (Grande and Vieira 2013). This link is achieved by integrating RFID into the supply chain.

5.3 Understanding Animal Identification and Traceability in the Study Area

Animal identification in the study area follows a dual practice of inconvenient and convenient methods. The coexistence of dual methods indicates two factors. Firstly, farmers view livestock as important assets or means of production contributing to livelihoods and personal worth. As such, ownership and the proof thereof are of importance. Both inconvenient and convenient methods of animal identification are used as appropriate mechanisms to ascertain ownership.

Secondly, the use of a dual practice indicates the level of confidence farmers have with respect to current methods of animal identification. The dual approach practice suggests that farmers are not able to prioritise one method over another in terms of its importance and effectiveness. The combined application of animal identification thereof enhances its effectiveness by ensuring that the possible weakness of one method is compensated by the strength of the other. If farmers had full confidence on the one method over the other, there would be no need for dual animal identification methods. At least, what would have been the case is that, some farmers would have used one method while others used the other. However, the study found that there was a high percentage of farmers who combined both animal identification methods, suggesting that each farmer used both inconvenient and convenient methods simultaneously.

The discussion about dual animal identification practices creates a good understanding of the current methods used by farmers in the study area. The other important dimension of this discussion is to determine whether any of the two methods currently used by farmers support traceability. The question whether a traceability system existed in the study area was measured using different approaches. On questions to determine acceptability of RFID, the following observations were made: 61% indicated that RFID will enhance animal recording, 54% suggested that RFID will enhance traceability, 76% agreed that RFID will ease isolation of affected animals and that 72 % concurred that RFID will enhance consumer confidence. The significance of this observation is the suggestion that currently, traceability of animals and animal products in the study does not exist. If it existed, these responses would not have been so emphatic in suggesting an anticipated future change in this regard.

Apart from the research findings, there is yet significant evidence suggested in the literature review. The current regulations in South Africa explicitly exclude information technology methods of animal identification. Given that traceability is almost synonymous with information technology, it is safely concluded that this study did not find any evidence suggesting that there is any form of animal traceability in the study area.

5.4 Impact of Current Animal Identification on Traceability

Now that the state of current animal identification has been determined and so are environmental factors; enablers: “farm-to fork”, “fork-to farm” philosophy, it is important to consider the impact of current animal identification. The impact of current animal identification on traceability or lack thereof can best be understood in relation to the number of activities of stakeholders that are in involved in the supply chain.

Even in a small circle such as Msinga, a network of players in the supply chain can be quite complex. Being at the centre, livestock producers are at the one end of the spectrum connected to suppliers of production inputs and customers at the other end. An example refers to medicines and animal vaccines. These products are supplied to livestock producers by retailers who may have sourced these from manufacturers. The medicines and animal vaccines manufacturers buy ingredients and packaging material from their respective suppliers. In the case of this example, inputs supplied to livestock farmers are used in the cause of production. Once the production cycle is complete, livestock producers supply live animals to buyers who in turn may, in the case of an abattoir; slaughter, process, package and distribute meet products to retail shops. Already, the networking process in the livestock production value chain appears quite complex and requires efficiency in recording and keeping information. If the production system is unable to capture all information regarding the supply of input and production, traceability will either be immensely compromised or may not be achieved at processing, packaging and distribution. Discussions in Section 5.2.1.7 above clearly suggested that there is no support for animal identification and traceability system at Msinga, this has severe implications for traceability of animals and animal products.

The point of origin is the primary level for data capturing about details of animals for it to be transferred to secondary levels in the supply chain such as the abattoir and so forth. The current animal identification system at Msinga and other rural areas of South Africa are not geared towards traceability. Therefore, animals sourced from these areas cannot be fully traced to the place of origin.

It is also important to indicate that lack of traceability in the study area is not entirely caused by livestock farmers, it is a broader problem. In countries where traceability is effective, it is because there is a national system of traceability which is managed by government or a designated authority. Example of such national traceability systems and authorities responsible were discussed sufficiently in Chapter 2. In fact, even before a national system, countries have put in place a regulatory framework. While legislation was sufficiently discussed in Chapter 2, it is important to further reflect on the South African situation regarding the traceability system. Apart from the work carried out by various provinces affected by FMD, the work by different beef abattoirs and plans to introduce ear tags on cattle in KZN, this study did not find any evidence suggesting that the South African government was planning to migrate to RFID.

It must be emphasised that the fact that RFID for animal identification has not been adopted, does not mean that there is not capacity for traceability systems in South Africa. Extensive work has been done to ensure that traceability is implemented in the fruit and wine industries in South Africa (Department of Agriculture, Forestry and Fisheries 2007, GS1 2008). The agricultural products of plant origin have an added advantage in that there is a clear regulation supporting traceability of these products. The Agricultural Products Standards Act (Act No. 119 of 1990) regulates standards of agricultural products destined for export markets.

Chapter 2 identified a gap in legislation in that while the Meat Safety Act (Act No. 40 of 2000) seeks to promote safety standards through traceability, the Animal Identification Act (Act No. 6 of 2002) is silent in this regard. It thus suggests that food quality and safety standards are not achieved with respect to the beef industry. A relatively well resourced country like South Africa should at least be taking cue from its neighbours such as Botswana and Namibia and adopt an animal identification and traceability system. This idea is even more compelling considering the fact that South Africa was recently banned from exporting beef products due to the FMD outbreak. This ban was lifted by OIE on condition that stringent measures to deal with and control FMD outbreaks are convincingly put in place.

5.5 The role of government

Implementation of RFID requires government involvement in a number of ways. Firstly, the government has a role to play with respect to passing legislation to enhance animal identification and traceability (Bai and Li 2014). Such legislation is important to provide a legal framework and guidance on compliance, particularly to maintain food quality and safety. Secondly, the government has a role to play in respect of food quality and safety (Republic of South Africa 2002). This will ensure that food products supplied to customers will not cause food incident concerns. Lastly, the government can play a role with respect to funding the introduction of RFID, especially in the case of resource-poor farmers (Skaggs 2011, Meat Board of Namibia 2012, Jenjezwa and Seethal 2014).

5.6 RFID as a Solution to Improve Animal Identification and Traceability

To address the question whether RFID has the potential to improve animal identification and traceability in rural areas, this section draws from the global experiences and conducts a statistical test. The global experience in this regard is based on literature review as discussed in Chapter 2, while the statistical test is based on research results presented in Chapter 4.

5.6.1 Experiences of Other Countries

In spite of its limitations and challenges, there is no doubt that RFID is useful in improving animal identification and traceability. Based on international experiences, RFID has been adopted by a number of countries to introduce better practices to manage animal diseases and outbreaks including BES and FMD. These countries include well developed economies like the US and European countries. Although there is sufficient evidence in literature suggesting that food safety has been the key driver for countries to adopt RFID, there are three other significant uses of RFID.

Firstly, countries have adopted RFID to manage the aftermath of animal disease outbreaks and to prevent its recurrence through proactive surveillance and isolation of affected animals. Chapter 2 clearly demonstrated that countries like the US and EU which have once been banned from international export were able to regain recognition after adopting RFID. To be able to regain international export status and consumer confidence on the basis of improved food safety is an indication that RFID is an effective technology to enhance traceability of animals and animal products.

The second reason why RFID has been adopted by different countries is for the purpose of accessing premium markets and expand the market share. In Chapter 2, it was demonstrated that the demand for food quality and safety is not necessarily conditional to animal disease outbreak. Consumers want to be guaranteed of the quality and safety of products, whether animal disease outbreaks have occurred or not. In addition to consumers, there are a number of organisations who are interested in knowing whether production practices have an impact on the welfare of animals as well as the environment (Schroeder and Tonsor 2012). To deal with the demand of these organisations, some countries have adopted RFID proactively. This also has a positive effect on product differentiation and consumer confidence. This is yet additional evidence that RFID is trusted to be an effective technology to enhance traceability.

Lastly, RFID is regarded as effective technology to improve production, management of inventory and bringing about efficiencies in the supply chain. The study has deliberated extensively on gains associated with product quality and safety offered to customers as this achieves product differentiation, competitive advantage and profit gains. For these reasons, this study is of the opinion that indeed RFID has a great potential to enhance traceability of products in general and animals and animal products in particular.

Based on the experiences of economies that have adopted RFID, it is clear that while this technology has some limitations with respect to functionality, there are a number of economic benefits. There are also negative consequences associated with operating outside the framework of the traceability system. The consequences are also very clear. They include poor access to premium markets, inability to differentiate products and lack of consumer confidence. Most importantly, countries that do not have traceability systems are easily banned from export markets in the event of viral disease outbreaks. This is because such countries are not able to prove beyond doubt that infection can be isolated and managed with expediency. Countries that have been banned from export markets have also lost a significant amount of trade. Even more compelling is the fact that countries may not be adopting traceability systems to save costs, but in reality, the cost of losing profit and reactive measures to control outbreaks are more likely higher.

5.6.2 Hypothesis Test

In addition to some theoretical constructs discussed in Section 5.2 above, there is still a need to conduct a statistical test. This study adopted a survey as research strategy to test the acceptability of RFID among the livestock farmers at Msinga. The purpose of the study was translated into the hypotheses presented in Chapter 1, i.e. Ho and H_1.

This Section presents the outcome of the statistical test conducted to determine whether to accept or reject the null hypothesis. A Chi-Square was used to test the hypothesis. This test was based on data collected from respondents based on the assumption that: (i) farmers will not accept RFID as a solution to improve animal identification and traceability; and (ii) farmers will accept RFID as a solution to improve animal identification and traceability. Data to these questions was collected randomly from 170 respondents.

The Chi-Square was calculated following six sequential steps outlined below. Further, in addition to the Chi-Square formula, the process relied on the “degrees of freedom” formula and determination of a Chi-Square Table value, which is based on both the degree of freedom and the level of significance (LOS) desired. The process of calculating the Chi-Square culminated in two important outcomes: the calculated Chi-Square value and the Chi-Square table value. These values were then plotted on a distribution curve known as “critical region” which is divided into two areas, the area of acceptance and the area of rejection. The decision to accept or reject the null-hypothesis was informed by the calculated Chi-Square value and the Chi-Square table value. The actual calculation of the Chi-Square followed six sequential steps as outlined below:

Step 1: State the hypothesis

H_0 (null hypothesis): Famers will not accept RFID as solution to improve animal identification and a traceability system.

H_1 (alternative hypothesis): Famers will accept RFID as solution to improve animal identification and a traceability system.

Step 2: State Level of significance

The desired LOS, (denoted as **α**) for this test is = 0.05. This is the most commonly used LOS.

Step 3: Test Statistic

A statistical test was conducted based on the Chi-Square formula below:

$$\chi^2_{calc} = \sum \frac{(f\text{o} - f\text{e})2}{f\text{e}}$$

Let: fo = observed frequency = frequencies of farmers not willing to accept RFID

fe = expected frequency = frequencies of farmers willing to accept RFID

It must be noted that the observations of farmers not willing to accept (fo) and those willing to accept (fe) used in the calculation of the Chi Square are based on the findings presented in Section 4.1.5 dealing with the question of acceptability of RFID.

Where: Degrees of freedom = $\sum \frac{\text{row marginal} - \text{colum marginal}}{\text{Expected}} = \frac{5-1}{1} = 4$

And: $\chi^2_{calc,}$ Denotes the calculated value of Chi Square

Therefore, using the observations presented in Figure 5-3 above, the χ^2_{calc} equals:

Table 5-2: Calculation of Chi-Square

	f_o	f_e	$f_o - f_e$	$(f_o - f_e)^2$	$\frac{(f\text{o} - f\text{e})^2}{f\text{e}}$

Strongly disagree	17	8	9	81	10
Disagree	37	7	30	900	129
Neither agree nor disagree	59	35	24	576	16
Agree	36	72	-36	1296	18
Strongly agree	21	48	-27	729	15
Σ	170	170	0	Σ (or χ^2_{calc})	188

Step 4, Critical Region:

Figure 5-4 below demonstrated two critical regions, area of acceptance, and rejection area.

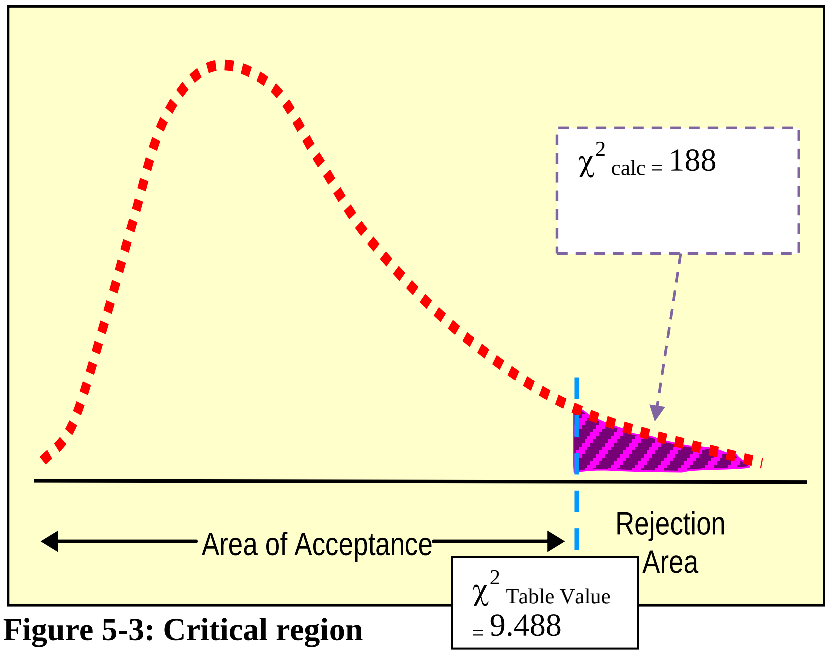

Figure 5-3: Critical region

Step 5: Decision Rule:

If the calculated Chi-square value is equal or greater than the Chi-Square table value, then **reject** the null hypothesis.

Step 6, Conclusion:

Since χ^2_{calc} (188) > α (0.05), = 188 > 9.488, the study fails to accept Ho (null hypothesis). There is sufficient evidence suggesting that at 95% or 0.05 LOS farmers will accept RFID as a solution to enhance animal identification and traceability.

5.7 Conclusion

The discussion of research findings in this Chapter was presented in three main sections. The first section focused on developing some theoretical constructs around animal identification and traceability. This was supported by the development of a toolkit serving as a checklist of all dimensions of radiofrequency identification that needs to be in place to give rise to effective traceability. This section also identified some environmental factors affecting animal identification in general and animal production in particular. Part of the theoretical constructs was to present an analysis of distribution of animals and animal products to consumers through the philosophy of "farm-to-fork" and "fork-to-farm". The presentation of theoretical constructs was largely based on the literature review.

The second part focused on analysis of the current status of animal identification within the study area. An effort was made to make sense of the impact of current animal identification to animal traceability. This was based largely on the research findings. The last part was concerned with the testing of the hypothesis using a Chi-Square test.

All three main sections of this Chapter sought to address two questions: firstly, whether current animal identification in the study area supports traceability and secondly, whether RFID could enhance traceability. The use of the toolkit developed as part of the theoretical construct, clearly indicated that the current form of animal identification in the study area does not support traceability. Also, this analysis indicated that even the legislation in the case of South Africa does not support traceability. Given that there was no evidence of animal traceability in livestock production, a traceability system starting at the abattoir stage of the value chain is almost of no use. Lastly the Chi-Square test indicated strong evidence that farmers in the study area will accept RFID as solution for animal identification and traceability. Chapter 6 synthesises the analysis of research findings and concludes the outcome of the study as well as present recommendations.

Chapter 6 Conclusions and Recommendations

6.1 Introduction

This final Chapter presents overall conclusions of the study and make recommendations on the use of RFID in a rural setting and its impact thereafter. Given that the study was partly triggered by the plan of the KZN Department of Agriculture and Rural Development to introduce RFID, recommendations presented in this Chapter reflect on whether this plan is worth pursuing.

6.2 The value of RFID in animal identification for rural livestock farmers

A quantitative approach was adopted by this study to collect data from 170 respondents at Msinga, a rural area in central KZN. Quantitative instruments to collect and analyse data were cautiously selected with a view to minimise errors and biasness and to enhance the quality of the study results. These instruments included the probability approach, random sampling, sample frame, objective calculation of sample size, structured questionnaires and the use of trained field workers to administer the questionnaires. During data capturing, trends of consistency in responses on similar questions asked differently were observed. Such level of consistency on findings was also on par with the existing empirical evidence discussed in Chapter 2. Coupled with the degree of correlation of responses obtained through the use of different instruments, consistency between research findings and empirical evidence indicated gains of carefully selecting research methods to minimise the margin of error.

Central to this study was to determine the value of applying advanced technology to deal with and solve rural problems. Key to this is acceptance of advanced technology by rural dwellers, in particular to improve animal identification and traceability. In addressing this question, it became important to understand animal identification practices as well as potential impact of RFID.

Literature review demonstrated that a number of first world economies have adopted RFID to enhance traceability systems. The primary purpose has been to guarantee food quality and safety to consumers. This was prompted largely by food safety incidents in US, Europe and other countries. RFID is triggered by a number of reasons, principal to them being customer demand for food safety through traceability. Other triggers include the need to improve supply chain efficiencies, management and monitoring of inventories, building competitive advantage, gaining access to lucrative international markets and profit gains.

The study found that animal identification at Msinga still relies on unauthorised methods of marking animals which are used alongside authorised methods. Nevertheless, none of these methods are supported by sophisticated information technology. As such, animal identification records are not well kept. As a result, there is no proper transfer of animal records from farmers to buyers. This has severe implications for maintaining traceability through the supply chain as traceability relies on good records on production at the farm level. The observations of the study findings indicate that current animal identification methods in the study area do not have the capacity to maintain traceability. It has also been demonstrated that new methods based on RFID would be accepted and are seen as having the potential to enhance animal records and traceability. This study has deliberated extensively on the risk of operating outside a traceability framework when the world economy is migrating to a traceability system. Penalties are clear and severe, market access and growing the beef economy becomes difficult.

6.3 Theoretical deduction

The study developed theoretical constructs, animal identification and a traceability checklist and "farm-to-fork" philosophy. These were based on literature review and on the findings of the study, and intend providing an analytical understanding of the intricacies of RFID. The theoretical constructs also serve as a yardstick to measure whether traceability exists, and also whether an environment is favourable for it to be implemented. Applying the developed theoretical constructs and a toolkit for RFID enablers, it became apparent that globally, the environment for implementation of RFID in South Africa is favourable. They include availability of international guidelines; RFID technology market pull factors are in place for any potential user to adopt this technology with ease. The South African situation including animal disease outbreak and the need to tap into premium markets clearly indicates that there is a need for the adoption of RFID. However, the major hindrance is the absence of appropriate legislation. Affordability might be a hindrance but this is not a major factor as solutions can be worked out.

6.4 Generalisability of the study

Due to carefully selected instruments for defining the population, selecting the sample and collecting data which minimised errors and biasness, as well as ensured consistency in responses, the sample was representative. As a result, it is concluded that the observations made on the basis of 170 respondents is generalizable to the entire population of 1 000 livestock farmers. This means that in the study, in the abaThembu and amaMchunu Traditional Councils, animal identification is not supported by traceability systems.

6.5 Recommendations

Given the absence of a traceability system in the study area versus the increasing consumer awareness and the demand for food quality and safety, the advancement of information technology and the global migration to RFID, the following recommendations are made:

6.5.1 Adoption of RFID

The study emphatically recommends that South Africa consider adopting RFID. The implementation of RFID can best be implemented as a national programme. The strength of RFID in countries that had adopted this technology has been that it has been implemented as a national initiative. The danger of implementing RFID randomly in the country is that gains made could negatively be affected by what happens in other parts of the country that are without a traceability system. The effort in the Karoo, Western Cape Province, where traceability system is in place in sheep production is refuted by the that this is not a national programme. The study of the Karoo sheep production in the Western Cape shows that in as much as farmers have developed their own traceability mechanism, its effect is very minimal because there is no system at a national level to support this initiative. Adoption of RFID proactively is most cost effective than continuous reaction to animal disease outbreaks and trying to mend industry image.

6.5.2 Legislation

It is clear that the Animal Identification Act (Act No. 6 of 2002) was not crafted with a traceability system or other forms of information technology in mind. In light of advancing information technology and an increasing need to participate in global trade, the Act needs to be amended to remain relevant for the foreseeable future. It is only reasonable that South Africa consider amending the Act to incorporate traceability systems. In particular reference to the adoption of the RFID, the Act would be required to regulate the adoption and implementation of traceability systems and regulate the activities of different stakeholders.

6.5.3 Establishment of a Designated Authority

A designated authority to become a custodian of the national animal identification and traceability system is necessary. This body would be responsible for implementing the promulgated Act for animal identification and traceability. Among others, an established authority would be responsible for planning, designing and actual implementation, of the RFID and mobilising funds for this function. Further, an established authority would also deal with compliance issues and regulation of activities of various stakeholders in the supply chain in relation to RFID. The body would also be responsible for securing data.

6.5.4 Financial support

Recommendation is made that government contribute directly towards the cost of implementing RFID and indirectly by incentivising farmers into complying with this technology. The reason for this is that it is difficult to pinpoint a single stakeholder to bear all costs because naturally, benefits spread across the supply chain. By virtue of being able to collect tax, government can use a proportion of these levies to invest backward in the cost of implementing the RFID. It is also clear that the resource-poor farmers may without doubt not afford the implementation costs. The fact is that in the event of animal disease outbreak, the economy suffers and government spends insurmountable amounts of money to correct the problem, this clearly justifies the financial supportive role of government in this regard.

6.5.5 Designing RFID Traceability System

Lastly, it is recommended that adoption of RFID takes place following a thorough process of planning and design implementation thereof. The RFID has three key elements. The design process must ensure that all elements of RFID: the infrastructure, ear tags and software have been considered. Introduction of RFID must be accompanied by a data repository and having a designated authority to be the custodian of data. Introduction of RFID that is not supported by all three elements (a tag, a reader and a server) would be futile.

6.6 Limitations of the study

Initially, this study anticipated that the rural setting of the study area would affect the response rate. During the survey this proved not to be the case as it was managed through the use of field workers to collect data. Based on the analysis of the findings of the study, other limitations are observed. They include the following:

i. Given that this research is quantitative in nature, there was no opportunity for obtaining in-depth motives for farmers' willingness to accept the RFID. Also the study is not able to test whether the livestock farmers at uMsinga would have the ability to implement, operate and maintain this high technological information system;

ii. The study was motivated by the idea that the KZN Department of Agriculture and Rural Development had a plan to introduce RFID among rural livestock farmers. In as much as the study provided a broad operational framework, it was not the scope of this study to develop a model for the implementation of RFID in a rural setting where there is no infrastructure for technology; and

iii. The study was not able to provide cost-benefit analysis of the RFID. This is an important limitation given that the population selected for this study falls under the low-income bracket and is relatively poor.

6.7 Recommended Future Research

The limitations of this study provide an opportunity for future research. The following topics are therefore suggested:

iv. Investigation of capabilities and enablers for rural livestock farmers to implement, operate and maintain RFID in sustainable manner;

v. Action research to develop a model for the implementation of RFID to rural livestock farmers using workshops and seminars; and

vi. Cost-benefit analysis of RFID by livestock farmers.

6.8 Conclusion

In conclusion, it is important to reflect on the study objectives, namely:

v. To understand the current animal identification and traceability systems among communal farmers at Msinga;

vi. To investigate the effectiveness of the current animal identification on traceability of meat products; and

vii. To test whether farmers will accept RFID as a solution to improve animal identification and traceability system.

Based on empirical evidence and data analysis of this study, the following three conclusions are made. Firstly, in the study area and in other rural areas with similar characteristics, livestock farmers rely on manual application of brand marks as a form of animal identification. This form of animal identification is supported by and regulated by the Animal Identification Act (Act No. 6 of 2002). This form of animal identification has noticeable weaknesses. The current animal identification method could be tampered with, and as a result, livestock farmers compliment this practice with unauthorised self-designed brand marks. Also, another major weakness of this form of animal identification, is that it does not support traceability and as such does not have the ability to effectively keep good records of animals and animal products.

Secondly, due to the fact that the current animal identification system in the study area is not capable of supporting good record keeping, this system is not effective with regards to gaining access to lucrative international meat markets. This is because one of the conditions for gaining access to these markets is a requirement to build consumer confidence regarding food safety and the quality of food. South Africa has previously been banned from export markets in the event of the outbreak of viral diseases such as the FMD. This is because in the absence of credible traceability systems, there is no effective way of disease surveillance, isolating the problem and convincing international markets that the problem is under control.

Lastly, the study sought to understand whether the livestock farmers at Msinga would accept the RFID. The answer to this question is with a high degree of confidence emphatic “Yes”. An analysis of the data collected shows that the majority of farmers believe that RFID will enhance proof of ownership and develop traceability systems, improve animal breeding and selection as well as support the effective upkeep of animal records. Further, the economic gains of traceability systems have been discussed extensively in this study. The study was not able to establish in detail, whether the livestock farmers would accept RFID because of gaining access to international markets. However, the study shows that countries that have adopted RFID benefit from accessing premium meat markets because they are able to sustain consumer confidence and are able to manage problems associated with the outbreak of viral diseases. The fact that the livestock farmers at Msinga showed acceptance of RFID is an advantage to South Africa should this technology adopted. This is based on the assumption that other livestock farmers in rural areas with similar characteristics as Msinga would be more than likely not accept this technology. Should RFID be adopted in the country, the challenge often associated with poor uptake of new technologies does not exist in this case. This is one of the values of this study.

It is concluded that the current animal identification in the area of Msinga is not capable of keeping good records for the purposes of production management. Countries both in well developed countries and emerging markets have adopted RFID to respond to both the market demands as well as to take advantage of advancement of technology. The existing legislation on animal identification in South Africa is outdated compared to other emerging markets. Although there may be questions regarding affordability and ability to implement RFID, the study concludes that the rural farmers of Msinga are ready to accept RFID.

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APPENDIX A: EARTHICAL CLEARANCE

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

05 March 2018

Mr Isaiah Mahlolani Mahlangu (901419850)

Graduate School of Business and Leadership

Westville Campus

Dear Mr Mahlangu,

Protocol reference number: HSS/1475/014M
New project title: Acceptability of Radiofrequency Animal Identification in rural KwaZulu-Natal

Approval Notification — Amendment Application This tetter serves to notify you that your application and request for an amendment received on 05 March 2018 has now been approved as follows:

- Change in Title

Any alterations to the approved research protocol i.e. Questionnaire/interview Schedule, Informed Consent Form; Title of the Project, Location of the Study must be reviewed and approved through an amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for period of 3 years from the date of original issue. Thereafter Recertification must be applied for on an annual basis.

Best wishes for the successful completion of your research protocol.

Yours faithfully

Professor Shenuka Singh (Chair)

/ms

cc Supervisor: Professor Muhammad Hoque cc Academic Leader Research: Dr Emmanuel Mutambara cc School Administrator: Ms Zarina Bullyraj

---

Humanities & Social Sciences Research Ethics Committee
Professor Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001 , Durban 4000
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100 YEARS OF ACAOEUC EXCELLENCE
FoundingCam-»use; Edgewood Howard Collage Medical School Pietermaritzburg Westville

APPENDIX C: REEARCH QUESTIONNAIRE

ACCEPTABILITY OF RADIOFREQUENCY ANIMAL IDENTIFICATION IN KWAZULU-NATAL

1. Personal information

1.1 Gender

Male	Female
1	2

1.2 Respondent's age

Below 20 years of age	Between 21 and 30 Yrs of age	Between 31 and 40 Yrs of age	Between 41 and 50 Yrs of age	Between 51 and 60 Yrs of age	Above 61 Yrs of age
1	2	3	4	5	6

1.3 Marital status of the respondent

Married	Single	Divorced	Widow	Widower
1	2	3	4	5

1.4 Number of dependants to the respondent

None	Between 1 and 4	Between 5 and 8	Above 9
1	2	3	4

1.5 Respondents' Level of education

	LEVEL
1	No formal education
2	The level of education is below Grade 7
3	Above Grade 7 but below Grade 12
4	Has Grade 12 but not Tertiary qualification
5	Has a Diploma
6	Has a University Degree

1.6 Respondents' level of income

	LEVEL OF MONTHLY INCOME
1	Below R1 000.00
2	Between R1001.00 and R3 500.00
3	Between R3 500.00 and R5 500.00
4	Between R5 501.00 and R7 500.00
5	Between R7 501.00 and R9 500.00
6	Between R9 501.00 and R11 500.00
7	Between R11 501.00 and R13 500.00
8	Above R13 501.00

1.7 Number of livestock owned by the respondent

		Cattle	Goats	Sheep	Horses	Donkeys	Pigs
1	Less than 10						
2	Between 11 and 20						
3	Between 21 and 21						
4	Between 31 and 40						
5	Between 41 and 50						
6	Between 51 and 60						
7	Between 61 and 70						
8	Above 71						

1.8 How long has the respondent kept livestock

	Period
1	Less than 1 year
2	More than one year but below 10 years
3	More than 10 years but below 20 years
4	More than 20 years but below 30 years
5	More than 30 years

2. What methods do farmers use in the area as form of animal identification to certain their ownership

2.1 Most livestock owners name their livestock as form of animal identification

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

2.2 Most livestock owners use the colour of the animals as form of animal identification

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

2.3 Most livestock farmers brand animals using random symbols they have created themselves

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

2.4 Livestock owners register for Animal Identification Certificate with the Department of Agriculture and Fisheries

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

2.5 Livestock owners brand their animals using brand marks provided in accordance with the Animal Identification Certificate

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

2.6 Livestock owners use a combination of self-created brand marks and brand marks provided for in accordance with the Animal Identification Certificate

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

3 Acceptance of Radio Frequency Animal Identification

3.1 Livestock owners gladly accept RFID because each and every animal would have unique identity

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

3.2 Livestock owners are reluctant to accept RFID on the basis that it will be expensive

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

3.3 RFID will increase confidence for livestock ownership thus deter stock theft

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

3.4 RFID will improve record keeping required for breeding and selection

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

3.5 RFID will provide production management information and increase consumer confidence

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

3.6 RFID will facilitate isolation sick animals for diseases management

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

4 Effectiveness of traditional animal branding as a management tool in respect to record keeping for breeding and selection

4.1 I believe that animal branding assist livestock owners to keep proper records in respect of breeding and selection

Not at all	Very little	Somewhat	To a moderate extent	To a large extend
1	2	3	4	5

4.2 Animal branding does not assist livestock owners to keep proper records in respect of breeding and selection

Not at all	Very little	Somewhat	To a moderate extent	To a large extend

1	2	3	4	5

4.3 Due to the fact that animal branding does not provide unique identification, it becomes difficult to isolate sick animals for disease management purposes

Not at all	Very little	Somewhat	To a moderate extent	To a large extend
1	2	3	4	5

4.4 During animal branding all records relating to the history of the animal is properly recorded manually

Not at all	Very little	Somewhat	To a moderate extent	To a large extend
1	2	3	4	5

4.5 Customers never ask for information on animal production and management regime

Not at all	Very little	Somewhat	To a moderate extent	To a large extend
1	2	3	4	5

4.6 During the sale of live animals, livestock owners, pass on records of the animals to the buyers

Not at all	Very little	Somewhat	To a moderate extent	To a large extend
1	2	3	4	5

PPENDIX C: TURNITIN REPORT

Acceptability of RFID

by Isaiah Mahlangu

Submission date: 02-Mar-2018 07:50PM (UTC+0200)

Submission ID: 924194954

File name: MBA__RFID_Research_02_March_2018.docx (754.7K)

Word count: 27941

Character count: 171630

Acceptability of Radiofrequency Animal Identification in Rural KwaZulu-Natal

Isaiah Mahlolani Mahlangu

Submitted in partial fulfilment of Masters in Business Administration

with

The Graduate School of Business & Leadership

University of KwaZulu-Natal

DECLARATION

I, Isaiah Mahlolani Mahlangu solemnly [redacted] original work conducted through the Graduate School of Business and Leadership, University of KwaZulu–Natal, under the supervision of Dr Muhammad Hoque. Scientific evidence supporting this study has been referenced appropriately. This work has not been submitted for another degree or to any other tertiary institution.

Signature of Student

--- ---------------------------

Isaiah Mahlolani Mahlangu Date

Signature of Supervisor

--- ---------------------------

Professor Muhammad Hoque Date

SUPERVISORS PERMISSION TO SUBMIT THESIS

ACKNOWLEDGEMENTS

I extend my greatest gratitude as follows:

- Glory to the Almighty for showering me with wisdom to undertake this amazing work;
- To the Apostle K T Mkhize of Mount Zion, Mpumalanga Township in KZN for holding my hand and being the father in spiritual journey;
- To Dr M Hoque, my supervisor, for academic guidance and training;
- To my beloved wife CD for everlasting love and support, May God bless you;
- To Ms Nompumelelo Mahlangu, Ms Nosipho Ayanda Mlambo and Ms Siphiwe Portia Mahlangu for rejuvenating my hope in life;
- To all members of my family; relatives and friends for your unwavering support;
- To fellow students, UKZN MBA 2012 Block Release, for your robust discussions;
- A special thanks to Mrs Phumla Mkhabela and Ms Sphiwe Mathonsi for inspiration;
- To my friend Mr Nyasha Mabaso who passed away just after our exams;
- To colleagues at the Department of Agriculture and Rural Development for your support;
- To the Msinga Livestock Association, Mthembu and Mchunu Traditional Councils for welcoming the study into the area;
- To Ms Gugu Mbatha and Mr Rauri Makhonya Alkock at MRDP for your support;
- To all interviewers for collecting data on my behalf; and
- Lastly, to my father Magwayi, for continued inspiration, love and leadership.

ABSTRACT

Globally, the beef industry has suffered from the Bovine *Spongiforum Encephalopathy* and Food and Mouth Disease (FMD) followed by a number of food safety incidents. This has caused a decline in consumer confidence, ban of export meat products and profit loss. In response, Radiofrequency (RFID) has been adopted to enhance "farm-to-fork" and "fork-to-farm" traceability to enhance quality control and food safety. The Department of Agriculture and Rural Development, in South Africa, has plans to adopt RFID. This plan necessitated the need to investigate whether the livestock farmers would or would not accept this technology. The null hypothesis developed suggests that the livestock farmers will not accept the RFID, while the alternative hypothesis suggests that they will.

A quantitative approach was used to conduct the study. Probabilistic and random sampling was followed to enhance the objectivity of the study. Data was collected from 170 randomly selected participants from a population of 1 000 livestock farmers, each with an equal probability of 0.1% of being selected. The research exercise was developed to minimise error and biases, enhance validity and reliability including improving the quality and generalizability of research results.

The study revealed that animal identification at Msinga relies on practical and manual practices without any technologically based traceability system. This is based on the fact that the South African legislation is not geared towards supporting traceability systems for livestock production. Empirical evidence shows that countries without traceability systems fail to gain access into lucrative international meat markets.

Based on statistical tests, the study fails to accept the null hypothesis. It is concluded at 95% level of significance, and there is sufficient evidence to suggest that livestock farmers in rural areas will accept RFID. Given that the world economy is migrating towards traceability to achieve product differentiation, gain consumer confidence and competitive advantage, it is recommended that South Africa consider adopting RFID. This can be achieved through amending the current Animal Identification Act, establishing a national animal identification and traceability system and appointing an authority to manage this programme.

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ABBREVIATIONS

BSE	*Bovine Spongiforum Encephalopathy*
CCIA	Canadian Cattle Identification Agency
CRM	Customer Relationship Management
EU	European Union
FANMAS	Farm Assured Namibian Meat Scheme
FAO	Food and Agriculture Organisation
FMD	Foot and Mouth Disease
HF	High Frequency
ICAR	International Committee for Animal Recording
ISO	International Organisation for Standardisation
LF	Low Frequency
LITS	Livestock Identification and Trace-Back System
NAIS	National Animal Identification System
NAIT	National Animal Identification and Tracing
NamLITS	Namibian Livestock Identification and Traceability System National
NLIRTS	Livestock Identification, Registration and Traceability System
NILS	National Livestock Identification System
OIE	World Organisation for Animal Health
QAS	Quality Assurance Standards
RFID	Radiofrequency Identification
SCM	Supply Chain Management
SGS	Argentina Animal Health Information System
SINIGA	National Livestock Individual Animal Identification System
SISBOV	Brazilian System of Identification of Bovine and Buffalo Origin
SNIG	National Livestock Information System
SPSS	Statistical Package of the Social Sciences
UHF	Ultra high Frequency
US	United States
WTO	World Trade Organisation

Chapter 1 : Introduction

1.1 Introduction

Radiofrequency Animal Identification (RFID) is the latest innovation adopted by livestock producers worldwide to improve, production management practices, consumer confidence and the market share. This Chapter presents the motive for an empirical analysis into this innovation with reference to its acceptability in emerging economies, particularly rural areas. The purpose of this Chapter is to introduce the subject matter, justification of the study and the use of RFID in animal production as instrument to enhance traceability systems.

For centuries, livestock farmers around the world have practiced some or another form animal identification as evidence for ownership. A strong sense of ownership helped farmers to present convincing evidence in courts of law with respect to stock theft cases. In recent years, there have been new triggers which required further improvements with respect to animal identification. The food safety incidents occurring globally over the past decades have resulted in consumers increasingly demanding assurance on quality and food safety (Shanaham, Kernan et al. 2009). In the 1990s, the outbreak of *Bovine Spongiforum Encephalopatyh (BSE)* or "mad cow disease" resulted in a 10 (ten) year ban of beef and dairy exports from Europe (Trevarthen 2007). Similarly, the outbreak of H5N1 in certain parts of South Africa and the 2011 Foot and Mouth Disease (FMD) outbreak in KwaZulu-Natal, resulted [redacted] a 3 (three) year export ban and a loss of R 4 billion worth of trade (Olivier, Fourie et al. 2006, GAIN 2014).

In pursuit of a solution to this complex problem, RFID was identified as a technology to improve and control production management in order to guarantee food safety. The introduction of the RFID implied significant transformation from what was once a simple method of animal identification into a more complex technological system of traceability. The RFID is recognised by the Worldwide Organisation for Animal Health (OIE) and International Committee for Animal Recording (ICAR) among other international organisations (OECD 2008). This technology has been adopted by many well developed global economies to improve disease surveillance and to respond quickly to animal disease outbreaks. With exception to a few countries like Botwsana, Namibia and Tanzania, emerging economies particularly in the African

Continent appear to trail behind. South Africa is among the countries that have not yet adopted the animal identification and traceability system. This is confirmed by the fact that the Animal Identification Act (Act No 6 of 2002) categorically exclude ear tags and electronics as methods of animal identification (Republic of South Africa 2002).

Implementation of RFID is associated with a number of benefits including the ability to enhance food quality and safety, penetration to premium markets, building consumer confidence, product differentiation and economic gains. The absence of traceability attracts market barriers particulalry in the event of viral animal disease outbreak. Implementation of RFID has not been without challenges. There is empirical evidence of reluctance to the use of RFID among farmers, especially in the United State (Skaggs 2011). This is because implementation costs are massive, but also, some farmers have suspected the intention of the government implementing RIFD (Skaggs 2011). In Botswana the system once suffered from lack of cooperation of stakeholders in the supply chain.

Animal identification and traceability systems have undergone at least two major phases. The first phase was a manual based animal identification method. This phase was associated with a very simplistic form of animal identification which aimed at ascertaining proof of ownership, through applying brand marks on animals. The second phase is technologically based and is very complex animal identification methods. This phase is aimed at ensuring traceability of products, managing animal disease outbreaks, improving distribution efficiency through the supply chain and ensuring quality and food safety. This is achieved through improving traceability of animals and products using RFID technology. In both cases, domestic laws and international guidelines have been put in place to maintain standards and practices of animal identification and traceability system. Failure to comply with domestic laws attracts penalties. At the same time operating outside the traceability framework has consequences. Producers of food products encounter difficulties penetrating premium markets in well developed economies. Also, in the event that there is viral animal disease outbreak, the beef and dairy industry is banned from export trade.

In South Africa, animal identification is regulated by the Animal Identification Act (Act No 6 of 2002 (Rebuplic of South Africa 2002). In terms of this Act, individual livestock owners are obligated to brand animals (Rebuplic of South Africa 2002). Anecdotal evidence and observations on livestock in rural KZN suggests that livestock owners barely comply with this Act. It is also worth mentioning that in spite of the Animal Identification Act, livestock theft in KZN is prevalent (Department of Community Safety and Liaison 2008). Lack of compliance with the Animal Identification Act makes it easy for thieves to steal animals since ownership can easily be disputed even in a court of law.

The Department of Agriculture and Rural Development (DARD) in KwaZulu-Natal, has a plan to introduce RFID among the livestock farmers in the rural areas of KZN. This would require a considerable resources and effort. Livestock production in KZN takes place in a dual system; in a controlled environment in commercial farming system and in a free ranging system in communal rural lands. Given that rural farmers keep 52% of livestock (cattle, goats and sheep) compared to 48% in commercial farming, animal identification and traceability system will need to prioritise communal farming area. This intervention would bring about a drastic change in livestock production management practices.

1.2 Problem statement

The successful implementation of RFID in KZN will ensure that the region is at par with the global animal identification and traceability systems practiced. However, the plan by the DARD to support farmers migrate from animal identification using brand marks to the RFID is dependent on a number of variables. There are obstacles that would need to be managed. Poor compliance with the current Animal Identification Act, might imply that there would be slow uptake of this technology. Livestock farmers without access to technology will be alienated from the benefits of this programme. There is evidence that in even well-developed economies livestock farmers have been reluctant to adapt to the RFID on the basis of increased production costs. Also, during animal diseases outbreaks, countries without advanced traceability systems, may be burned from the global meat markets. There is one more huddle to deal with. Acceptability of technological solutions is an important factor in the equation.

1.3 Motivation of the study

This study was motivated by the interest to test whether in a world affected by challenges of stock theft, market scepticism, would technological solution in livestock production be practical in rural areas of KZN. The approach to test this question was to assess the level at which RFID would be accepted. The interest was also to assess the level of acceptability in rural areas of South Africa when even in some well-developed economies acceptance level is low. This is even more compelling in consideration of the fact that the study area is associated with high level of illiteracy and poverty.

1.4 Research Objectives

The study aimed to achieve the following objectives:

(i) To understand the current animal identification and traceability systems among communal farmers at Msinga;

(ii) To investigate the effectiveness of the current animal identification on traceability of meat products; and

(iii) To test whether farmers will accept RFID as a solution to improve animal identification and traceability system.

1.5 Research Questions

To address the objectives of the study, the following broad questions were asked:

(i) What are current animal identification and traceability systems among communal farmers at Msinga?;

(ii) Is the current animal identification effective on traceability of meat products?; and

(iii) Will farmers accept RFID as a solution to improve animal identification and traceability system?

1.6 Focus of the study

The environment of animal identification in KZN is dynamic. On the one had there is no doubt that improved animal identification has a potential to deter stock theft. The introduction of RFID would deal with a potential threat of exclusion from global meat and livestock product markets in the event of the outbreak of animal viral disease. On the other hand, the introduction of RFID demands some levels of ability to understand and operate technological solutions. At the same time, RFID would bring additional production costs. The focus of the study is to analyse the acceptability of what could be regarded as "high technology solution" with cost implications into the rural areas of KZN which is often associated with high level of illiteracy and poverty.

1.7 Expected limitations

Given the undulating terrain of the study area and the centeredness of the settlements, finding reliable records from which to establish a credible sampling frame was a challenge. The records kept by the Dip Tank Committees in the eighteen villages that formed part of the study area, were the primary source of information. The credibility of this information depends on the willingness of livestock farmers to maintain these records. The second challenge, again relating to the set-up of the rural villages, contributed to 85% response rate as opposed to 100% response rate which was initially intended.

1.8 Thesis structure

This study is divided into the following six (6) chapters. Below is the synopsis of each chapter.

Chapter 1 introduces the subject matter and presents justification and relevance of the study. This Chapter describes the problem statement and the study area as well as set out research objectives and key questions. Lastly, the hypothesis of this study is whether sophisticated technology is acceptable as a mechanism for improvement of livestock production management practices and addressing food traceability problems facing emerging economies in general and rural communities in particular or not.

Chapter 2 discusses the phenomenon of animal identification and traceability based on empirical evidence reviewed for this study. The Chapter defines key concepts used in the study; describes the technical aspects of RFID and deals with aspects of legislation, guidelines and standards. Further, Chapter 2 shows that RIFD has been adopted mainly in developed economies not only at a farm level, but to improve supply chain, guarantee food safety and gain competitive advantage through product differentiation and consumer confidence.

Chapter 3 discusses research instruments carefully selected to conduct this study. This Chapter intelligently demonstrates how these research instruments were applied to minimise margin of error in order to enhance the quality and credibility the study result.

Chapter 4 presents findings of the study obtained using the interviewer-administered questionnaire.

Chapter 5 presents a critical analysis of the findings. In making sense of the findings, an animal identification and traceability toolkit as well as theoretical constructs to test observations are used to analyse the impact of the current animal identification on traceability, reflects on how RFID works in other countries; focuses on the consequences of lack of RFID in South Africa; and finally conducts a statistical test to address the hypothesis of the study.

Chapter 6 provides a conclusion and recommendations of this study.

Chapter 2 Literature review

2.1 Introduction

This Chapter presents different perspectives on animal identification and traceability based on existing studies. Large volumes of literature exist on this subject, most of which is based on the experiences of the first world economies. Animal identification is an ancient practice to ensure proof of ownership and prevent thievery. This practice has since evolved as technology advances. In its modern form, animal identification and traceability promise enhanced livestock production management and distribution of animal products through a complex supply chain in a most seamless and efficient manner. In contrast to its original purpose of ensuring ownership, efficient animal identification and traceability system carers for the interest of many stakeholders involved in the supply chain. Most importantly; animal identification and traceability systems guarantee transparency to customers on how food products are produced; processed; and distributed. Availability of information on products addresses issues of food quality and safety. Incorporation of traceability systems in the supply chain is driven by increasing awareness of consumers on food quality and safety. RFID had been adopted by many global economies to achieve animal identification and traceability. Emerging economies in the African continent, including South Africa, trails behind first world economies in this regard. To provide a clear understanding of the role of RFID, this Chapter guides the reader through the following Sections:

i. Section 2.2: Background of animal identification and radiofrequency traceability;
ii. Section 2.3: Definition and conceptual framework
iii. Section 2.4: Components, Types and operating frequencies of RFID;
iv. Section 2.5: Regulatory framework;
v. Section 2.6: Driving factors for adoption of RFID;
vi. Section 2.7: Cost-benefit analysis;
vii. Section 2.8: The cost bearer dilemma;
viii. Section 2.9: Acceptance of RFID;
ix. Section 2.10: Animal identification and traceability in South Africa;
x. Section 2.11: Traceability in other commodities in South Africa; and
xi. Section 2.12: Risks and limitations of RFID.

2.2 Background of Animal Identification and radiofrequency

The Practice of animal identification is quite ancient. It has been practiced by livestock farmers to apply random pertain of brand marks on animal bodies since 3 800 years ago (Sehularo 2010). It is suggested that, "this practice was first used to mark valuable animals like horses" to curb thievery (Bowling, Pendell et al. 2008, Moreki, Ndubo et al. 2012). However, the outbreaks of animal diseases first experienced in the 14th Century through to the 17th Century such as the "rinderpest, contagious bovine plearopneumonia, glanders, and rabies" shifted the focus from prevention of thievery to disease monitoring (Bowling, Pendell et al. 2008:p287). The awareness about safety of animal products preoccupied consumers (Bowling, Pendell et al. 2008). In the 18th Century, when the animal disease outbreak persisted in Europe, requirements for farmers to demonstrate proof of origin for animals in the form of a certificate were demanded by the markets (Moreki, Ndubo et al. 2012).

In response to the demand for food safety, animal identification started to evolve. Animal identification started in individual farms, spreading to groups and organisations of farmers and eventually being embraced by nations. This ripple effect spread and created a network of nations across the globe sharing mutual concerns and interest on animal identification. As this took place, organisations interested in livestock development, animal health and animal welfare emerged. International advocacy groups concerned with animal health and animal welfare have since emerged. Examples of advocacy groups include the World Committee on Animal Health (OIE) and the International Committee on Animal Recording (ICAR). As nations introduced laws regulating animal identification, interested organisations developed guidelines and standards for globally acceptable animal identification practices.

Once it had been acknowledged that a system of traceability in livestock production was required, RFID was identified as an appropriate solution. The RFID was first invented to monitor military aircrafts during World War II (OECD 2008, Reddy 2011, Hogan, M et al. 2016, Charles, Nandin et al. 2017). It then spread to the field of health and the supply chain of many other industries (Ene 2013). Apart from military services, the supply chain was the first sector to integrate RFID in its business management and operations (Reddy 2011, Hogan, M et al. 2016). Today, RFID is widely used in retail shops to label products, in hospitals to track patients, equipment and pharmaceutical products and in airlines to track passenger's baggage (Sarma 2010). Although the first generation of RFID for livestock became available in the mid-1970s, it is only in the late 1960s that it has been used intensively (Eradus and Jansen 1999, Trevarthen 2007). The demand for the commercialisation started to increase and is regarded as one of the fastest growing industries. (OECD 2008). It had been anticipated that the RFID industry would grow to $ 3 billion by 2010, and $26.23 billion in 2016 (OECD 2008).

Since the 1990s, a number of countries worldwide started to adopt animal identification and traceability systems in cattle production. However, others like France introduced a national bovine identification and traceability as early as 1978 (Marguin 2010). The European Union (EU) adopted the traceability system in 1997 which started as voluntary but became mandatory in 2000 (Bowling, Pendell et al. 2008). While Australia first introduced bovine animal traceability in the 1960s through the Brucellosis and Turberculosis Eradication Campaign, she only adopted National Livestock Identification System (NILS) in 1999 (Bowling, Pendell et al. 2008). In New Zealand animal identification and traceability system was adopted by the end of 2006 (Bowling, Pendell et al. 2008). In Namibia, the government established the Farm Assured Namibian Meat Scheme (FANMS), with a task to create the Namibian Livestock Identification and Traceability System (NamLITS) to meet the export requirements of the EU (Bowling, Pendell et al. 2008). In Botswana, the Livestock Identification and Trace-Back System (LITS) was introduced in 2001 in order to meet the requirements of the EU (Bowling, Pendell et al. 2008).

Table 2-1 below lists countries that have adopted animal identification and traceability systems since the late 1990s (Bowling, Pendell et al. 2008, United Republic of Tanzania 2010, Skaggs 2011, Meat Board of Namibia 2012, Moreki, Ndubo et al. 2012, Schroeder and Tonsor 2012).

Table 2-1: List of countries that have adopted RFID

Country	Date	Name of System
European Union	1997	Individual member state introduced respective systems
Australia	1999	National Livestock Identification System (NLIS)
Botswana	1999	Livestock Identification and Trace-Back System (LITS)
Brazil	2002	Brazilian System of Identification of Bovine and Buffalo Origin (SISBOV)
Canada	2002	Canadian Cattle Identification Agency (CCIA)
Japan	2003	The Cattle Traceability Law
Mexico	2003	National Livestock Individual Animal Identification System (SINIGA)
South Korea	2004	South Korea beef traceability system
United State	2004	National Animal Identification System (NAIS)
Uruguay	2006	National Livestock Information System (SNIG)
New Zealand	2006	National Animal Identification and Tracing (NAIT)
Argentina	2007	Argentina Animal Health Information System (SGS)
Tanzania	2010	National Livestock Identification, Registration and Traceability System (NLIRTS)
Namibia	2011	Namibian Livestock Identification and Traceability System (NamLITS)

2.3 Definition and conceptual framework

This Section defines two concepts associated with animal identification. First an effort is made to contextualise the concept of “animals”. Then, animal identification is categorised into two: the “traditional animal identification” and the “conventional animal identification”. A thorough definition of these two concepts is presented. The “conventional animal identification” incorporates the definition of ‘traceability” and “RFID”. Furthermore, different components, types and frequencies of RFID are discussed. This ensures that the reader has a clear understanding of how RFID technology is designed; implemented and functions.

2.3.1 Animals

The term "animal" is very broad and is inclusive of a wide range of wild game and domesticated animals (food producing animals and pets). The use of animals in this study is biased towards animals that are used to produce meat food products particularly for commercial purposes. A large volume of literature reviewed for this study is also biased towards animals associated with the meat industry. Such literature views animals and animal identification from the perspective of commercial livestock producers generally and consumers in particular. Animals are regarded as assets and means of production. Viewed as assets or means of production, ascertaining a sense of ownership becomes crucial.

2.3.2 Traditional methods of animal identification

Animal identification is defined as the process of "... registration of an animal individually, with a unique identifier, or collectively by its epidemiological unit or group with a unique group identifier" (Moreki, Ndubo et al. 2012:p926). Identification of animals is a tool for record keeping used on farm management including surveillance, containment, eradication and prevention of spread of diseases (Becker 2005). Globally, farmers have maintained animal identification and record keeping using various methods for many centuries. These methods include branding, ear notches and tattoos (Bowling, Pendell et al. 2008, Voulodimos, Patrikakis et al. 2010). Branding is achieved through a hot-iron or freeze branding using dry ice or liquid nitrogen (Voulodimos, Patrikakis et al. 2010).

2.3.3 Conventional methods of animal identification

Conventional methods refer to modern means conducted with information technology support. Conventional animal identification involves traceability system. RFID is identified as the most effective traceability system.

2.3.3.1 Traceability

In production industries, traceability means that all products and ingredients applied in production, processing and distribution are able to be traced to the source (Berevoianu, Buiga et al. 2011). Traceability is the ability to trace feed, food-producing animals and substances used in the process of production as well as the entire value chain (Chang, Tseng et al. 2013). This definitions concurs with the popular definition by ISO 8402 defining tractability as the "ability to trace the history, application or location of an entity by means of recorded identifications" (GS1 2008). Distribution of goods from producers to consumers takes place through a complex supply chain. It is critical therefore that products and its ingredients are traced through all stages of production, processing, and shipping until food products reach the consumer (Kernanb, Ayalewa et al. 2009). Further, traceability has the ability for forward tracking, that is "from raw material to markets", "from the farm to the table" or from "farm to fork" (Choe, Park et al. 2009, Ene 2013). It also has the ability for downward tracking, that is "from plate to source" (Ene 2013). Traceability system intends to provide information to consumers timely, actively and faithfully through the use of information technology (Bai and Li 2014).

2.3.3.2 Radiofrequency identification

RFID is defined as a tag "... that incorporates an integrated circuit, an antenna and memory that can store information. The tag interacts using electromagnetic waves, with a reader/writer that is connected to a computer that processes data from the tag and sends the data to the information system of the company" (Azuara, Tornos et al. 2012:p341). RFID incorporates the use of electromagnetic coupling in the radio frequency (RF) portion of the electromagnetic spectrum to transmit data (OECD 2008, Reddy 2011). It is a systems technology which enables two main points to interact, namely the reader and the tag (Sarma 2010). Basically, it is a system that transmits the identity, usually a serial number of an object using waves (Trevarthen 2007).

2.4 Components, Types and Operating Frequencies of RFID

The RFID is made up of three main components and comes in a number of forms and types varying in strength, size and quality. With respect to functioning, RFID is limited by the level of frequency or range. It is important therefore that technical dimensions of RFID as discussed below are well understood.

2.4.1 Components of Radiofrequency identification

RFID consists of three components; a tag, a reader and a server (Li and Liu 2011, Charles, Nandin et al. 2017). RFID is an integrated circuit that is coupled to an antenna, and covered and protected by the encapsulation. Depending on the working environment, the encapsulation provide protection against dust, extreme temperatures, moisture, heat and salt (Azuara, Tornos et al. 2012). Tags can be classified into three types, namely: active-tags, semi-passive tags, and passive tags.

A passive tag is not equipped with any form of power or batteries. This tag manipulate incoming electro-magnetic energy generated by the reader to power up an integrated circuit to transmit a response, (OECD 2008, Gastermann, Stopper et al. 2010, Maillart, Kamrani et al. 2010, Li and Liu 2011, Fazzinga, Flasca et al. 2016). As such passive tags are of low cost, relatively poor regarding performance (Li and Liu 2011). The limited storage capacity and read-range reliability is compensated by the fact that the device is cheaper and smaller (Trevarthen 2007).

Active tags are equipped with, usually a batteries (Trevarthen 2007, OECD 2008). Because of this, active tags are able to transmit data on a greater range, up to several hundred meters (Gastermann, Stopper et al. 2010, Maillart, Kamrani et al. 2010, Azuara, Tornos et al. 2012). The limitation of an active tag is that "...they are much larger than passive tags and significantly more expensive" (Azuara, Tornos et al. 2012:p347).

Readers, also called interrogators read data by sending "... a pulse of energy to the tag and listens for the tag's response. The tag detects this energy and sends back a response that contains the tag's serial number and possibly additional information" (OECD 2008:p16). Readers gather data by talking with tags over an RF channel (Reddy 2011, Fazzinga, Flasca et al. 2016).

Depending on the type and strength of devices used and the operating environment, reading processes can be simple and quick or complex and time consuming. Interference in the environment can be mitigated by putting an anti-collision control to avoid confliction of messages (Reddy 2011). Hand-held scanners are battery powered, while fixed scanners are usually connected to the power supply (Sarma 2010).

A server is comprised of data capturing computer and a storage software system. A server is usually kept at a strategic location with controlled access. Only designated authority must gain access to ensure the safety and upkeep of information. Without a server, tags alone and readers would not fulfil a complete loop of traceability circle. Generally, animal identification and traceability have the potential to create massive volumes of data. As data increase exponentially, the need to migrate from "computation-centric to data-centric" arises (Chen, Yin et al. 2013). This migration is supported by the use of cloud computing method. Cloud computing is simply a way of using virtual data processing and storage server away from physical offices (Chen, Yin et al. 2013, Seco and Jimenez 2018). Data is stored and downloaded as required without actually seeing or being able to touch the server.

2.4.2 Types of RFID

Three types of tags used in animal identification include: ruminal boluses, ear tags and a glass encapsulated microchip (Bowling, Pendell et al. 2008, Voulodimos, Patrikakis et al. 2010). Ear tags are attached in the ear of the animal, microchip is inserted under the skin while the bolus is implanted in one of the first two stomachs of the ruminant (Travarthen 2007, Reddy 2011). Respective countries may adopt any of the three types of RFIDs depending on identified need. For example, in Namibia individual cattle are identified using ear tags with a registered bar code and an animal unique serial number (Bowling, Pendell et al. 2008). In Botswana rumen boluses are used. Each tag may be coded with: owner's name, personal identification number; the brand of the animal; colour of the animal and the location (Bowling, Pendell et al. 2008).

2.4.3 Operating standards and frequency bands

RFID frequencies (*fi*) is denoted as follows: [*f*min, *f*max], where *f*min and *f*max represents minimum and maximum band frequencies respectively (Neganov, Plotnikov et al. 2012). The frequency is arranged in ascending order and is denoted as $f_i < f_{i+1}$ (Neganov, Plotnikov et al. 2012). The higher the frequency band the more effective the RFID tag will be. Frequency of the passive tags ranges between [redacted] while active tags often operate in the Ultra-High Frequency (UHF) and microwave frequency bands (OECD 2008). Operating in LF-HF can easily be interfered with by the close proximity of metals and liquids (Reddy 2011).

It is the responsibility of respective of countries to establish bodies of authorities to regulate the use of RFID. However, various international authorities exist to set standards for RFID. The ICAR developed in 1995 a set of requirements regarding (among others) the reading distance and reading speed. The International Organisation for Standardisation (ISO) has published standards for RFID on livestock (Kernanb, Ayalewa et al. 2009). Among others, these standards determine the operating frequencies: LF and HF as well as UHF and Microwave (Kernanb, Ayalewa et al. 2009). These frequencies vary in range, for example, LF ranges between 120 KHz to 140 KHz, while HF ranges between 850 MHz to 950 MHz and 2.4 GHz to 2.5 GHz (Voulodimos, Patrikakis et al. 2010, Reddy 2011). KHz is a unit of electromagnetic wave frequency which is equal 1 000 per second. In some cases, even HF tags are not sufficient. The highest operating range is the UHF and Microwave. The UHF ranges between (868 MHz to 928 MHz) while the Microwave ranges between 2.45 and 5,8 GHz) (Reddy 2011).

2.5 Regulatory framework

Regulatory framework is a requirement for animal identification and traceability system to maintain compliance and set standards. Operating within a set regulatory framework is supported globally by advocacy organisations such as the OIE, the World Trade Organisation WTO, the Food and Agriculture Organisation of the United Nations (FAOU), and Codex Alimentarius (Schroeder and Tonsor 2012).

While it is not practical to have a universally accepted law, international guidelines on animal identification and traceability systems have been developed. These are then observed through international treaties. Schroeder and Tensor, 2012, observe that OIE has 175, WTO 153 and Codex have 184 member countries affiliating to these respective international organisations. This affiliation facilitate compliance with: international guidelines on animal identification and traceability; management of livestock production; animal diseases control; animal health and welfare; traceability of products; meat hygiene; and quality and safety of food products (Schroeder and Tonsor 2012).

A number of countries around the globe seeking to adopt livestock identification and traceability systems pass relevant laws regulating this function. First world economies have been proactive in this regard. Emerging economies in Southern African like Tanzania, Botswana and Namibia have introduced laws regulating animal identification and traceability system mainly for trade (United Republic of Tanzania 2010, Meat Board of Namibia 2012, Moreki, Ndubo et al. 2012). While there is emphasis on livestock management and food safety assurance, introduction of animal traceability to reduce stock theft features significantly in developing countries (Toto 2010, United Republic of Tanzania 2010).

In South Africa, animal identification is regulated by the Animal Identification Act (Act No. 6 of 2002) (Republic of South Africa 2002). The Act makes provision for all livestock owners to register for authorised animal identification marks and apply these on their animals as prescribed by the law (Republic of South Africa 2002). The Act defines animal identification mark as "... mark registered in terms of section 5 (2) and placed on any animal..." (Republic of South Africa 2002:p2). This Act categorically excludes other forms of animal identification, such as mark made with paint, tag attached on the ear, notch or hole (Republic of South Africa 2002). The Animal Identification Act is limited to visual animal identification which ignores electronic traceability mechanisms.

2.6 Driving factors for adoption of RFID

In recent years animal identification and traceability has been prioritised for a range of reasons. These include farm management, disease control, meeting export requirements and meeting consumer demands for food quality and safety (Moreki, Ndubo et al. 2012). Further, consumers are increasingly becoming conscious about food safety and therefore shifting towards buying food products that can be traced to source (Glynn and Schroeder 2006). Global demand for intensification of food production and the need for agriculture to contribute to economic growth means that production efficiencies and management of inventories must equally be improved (Besbes, Hoffmann et al. 2010). Distribution of food products through the supply chain exposes these inventories to theft and contamination. Increased awareness of consumers about food [redacted], has necessitated the provision of detailed product information to consumers (Besbes, Hoffmann et al. 2010, DOINEA, BOJA et al. 2015). Key drivers for RFID including improvement of farm management; supply chain management; marketing; commercial factors; and lastly food safety incidents are discussed in this section.

2.6.1 Improvement of farm management

In livestock production, traceability fulfils three important aspects, animal identification, premises and owner registration and lastly animal movement control (Salina and Azmie 2013). Traceability enables livestock producers to identify individual animals, manage the movement of animals and improve disease surveillance (Schulz and Tonsor 2010, Sehularo 2010). However, animal identification and traceability system is also used to prevent thievery (Besbes, Hoffmann et al. 2010, Smiley 2015).

At a farm level RFID improves efficiency and reduce costs by elimination of labour cost, reduction of error in reading data, and introduction of automation feed monitoring (Eradus and Jansen 1999, V and R 2017). Traceability is necessary for the eradication of some animal diseases, herd management and cattle trade (Marguin 2010, Sehularo 2010, Toto 2010, United Republic of Tanzania 2010). It also helps to reduce fraud, track stolen stock, help with disease surveillance and improve stock record keeping as well as herd-book administration (Staake, Michahelles et al. 2010, V and R 2017). Traceability provides farmers with an "... efficient way to identify source of and quickly solve animal production problems that affect overall value of animals throughout production and processing" (Schulz and Tonsor 2010:p659).

2.6.2 Improvement of supply chain management

In the supply chain management (SCM), the RFID is adopted for its ability to identify objects and transmitting such information using electromagnetic waves (Sobottka, Leitner et al. 2012). Its main use is to track and trace the movement of goods and products with a view to improve efficiency and certainty of delivering at the right time and place (Sarma 2010, Dangage, Radia-Melis et al. 2016). It also enables companies to determine shrinkage of products caused by theft or damage as well as estimates delivery time (Hardgrave and Miller 2010, Zimerman 2011, Anna, Ronn et al. 2017, Bibi, Guillaume et al. 2017). In this scenario, RFID is used as "… an indirect way to infer whether a product has remained within the legitimate supply chain, and to assure its pedigree"(Sarma 2010:p29).

RFID creates a link between producers and consumers through the supply chain by ensuring that there is continuity of traceability beyond the point of slaughter (Grande and Vieira 2013). During distribution, RFID enables stakeholders in the supply chain to determine the exact position, in real time, of products until delivery is made (Grande and Vieira 2013). Organisations require traceability systems that fulfils internal operations, but that are also able to communicate easily across industries domestically and internationally (van der Merwe and Kirsten 2013, Dangage, Radia-Melis et al. 2016).

2.6.3 Marketing

Traceability system serves as means to gain access to the international premium beef market (Salina and Azmie 2013). It is argued that RFID is "an increasingly important factor in current global markets characterised by high competitiveness in quality."((Azuara, Tornos et al. 2012: p341). Beef exporting countries are gradually adopting RFID to meet international standards for food safety and to increase market share (Schroeder and Tonsor 2012).

To offer customer value, measured quality assurance standards (QAS) "... have been implemented in many production environments. These systems include the use of certification marks by the producer, traceability system, third-party audits and affidavits from producers" (Azuara, Tornos et al. 2012:p341). It is argued that "QAS improve the brand image, differentiating it from competitors and enhancing consumer confidence …" (Azuara, Tornos et al. 2012:p341). Firms which are able to respond to consumer demand for information about products on offer, set themselves apart from their peers and thereby gain a competitive advantage (Chang, Tseng et al. 2013). This way, the traceability system becomes a means for market differentiation. Compliance with market standards is a strategic mean to penetrate niche markets (Bowles, Paskin et al. 2005, Glynn and Schroeder 2006). Countries such as Namibia and Botswana have managed to penetrate EU export markets through this system.

2.6.4 Food Safety Incidents and Increasing Consumer Awareness

Efforts made by livestock producers to meet the global market demand for food quality and safety has in the past 3 (three) decades suffered from various food safety incidents (Ahoya and Glaze 2009, Besbes, Hoffmann et al. 2010, Voulodimos, Patrikakis et al. 2010, Feng, Feng et al. 2013). The outbreak of the BSE in 1996 and in 2002, is one of the catastrophes that has had a huge negative impact in the beef industry (Trevarthen 2007, Besbes, Hoffmann et al. 2010, Buskirk, Schweihofer et al. 2012). The BSE outbreak in 1996 affected the beef trade in the EU and in particular exports (Velez, Sanchez et al. 2013, Hogan, M et al. 2016). This crisis resulted in a 10 year EU ban of cattle and beef exports from Britain, a decline in consumer confidence and profit margin loss (Kernanb, Ayalewa et al. 2009). Food safety concerns are key drivers for traceability, especially in well developed economies such as the EU and the US (Moreki, Ndubo et al. 2012, Rebala, Alina A et al. 2016, Omarov, Agrakov et al. 2017).

Besides the BSE, there has been a number of food accidents including: "lean meat"; "poisonous milk powder"; "Sunden red"; and "ripener" (Bai and Li 2014). The outbreak of H5N1 avian influenza in South Africa and later FMD in February 2011 raised serious concerns among consumers globally (Olivier, Fourie et al. 2006, Aung and Chang 2014, GAIN 2014). The beef industry in South Africa suffered horsemeat scandal in 2013 following mislabelling of horsemeat as beef and exporting it to 15 countries in Europe (Clark 2013). All this has made consumers to be cautious about "...what they eat, whether food is from a sustainable source, whether it is produced using eco-friendly methods, and whether the production, transportation and storage conditions guarantee food safety" (Chang, Tseng et al. 2013:p1363). Besides food safety incidents, the market uncertainty of the impact of the use of antibiotics in livestock farming to human health is a concern. It is estimated that in the US alone, antibiotic-resistant infections cause an estimated 23 000 deaths per year (Chang, Wang et al. 2014). While it is difficult to prove the threat of agricultural antibiotics beyond reasonable doubt, the perception of it being harmful has resulted in consumers desiring antibiotics free meat products (Aung and Chang 2014, Chang, Wang et al. 2014, Matindoust, Baghaei-Nejad et al. 2016). This further strengthens the argument for introduction of traceability systems in the value chain.

To deal with food safety incidents, RFID provide credible information about the origin of beef products (Besbes, Hoffmann et al. 2010, Voulodimos, Patrikakis et al. 2010, Velez, Sanchez et al. 2013). This system provides reliable information to enhance food quality and safety and allows the verification of quality at any point of the production process, processing and distribution of products (Azuara, Tornos et al. 2012, Ene 2013, Bibi, Guillaume et al. 2017, Saba 2017).

2.6.5 Economic factors

RFID has gained attention from business executives because of its potential to improve commercial activities and operations, increase profits and enhance competitive advantage (Park, Koh et al. 2010). RFID has a potential "... to transform all areas of business: manufacturing, transportation, distribution, warehousing inventory, sales, marketing, and customer services" (Park, Koh et al. 2010:p683). Businesses are able to track products, cases and pallets to support planning, decision making, SCM and customer relationship management (CRM) (Park, Koh et al. 2010). RFID allows business to manage inventory accurately, improve security against product shrinkages, improve traceable warranties and targeted product recalls, brings efficiency and reduce processing time and labour (Park, Koh et al. 2010, Badia-Melis, Mc Carthy et al. 2018). In this way, companies are able to reduce production costs and increase profit margins.

2.7 Cost benefit analysis

The risk of food incidents is not only a threat to human health; however, lack of consumer confidence also affects the commercial health of businesses. It is observed that consumers' perception of food incidents influences purchasing behaviour (Choe, Park et al. 2009, Anna, Ronn et al. 2017). Shortly after the outbreak of the BSE, beef sales in Europe dropped significantly to 40% in France, 60% in Germany; 42% in Italy; and 30% in Portugal (Choe, Park et al. 2009). With the incident of the BSE in 2004, the export restrictions in the US caused a loss ranging between \$3.2 billion to \$4.7 billion in 2004 alone as a result to restriction of trade (Skaggs 2011, Schroeder and Tonsor 2012). In South Africa the outbreak of FMD in 2011 resulted in the ban of red meat export being imposed by the OIE and a R4 billion loss worth of trade (GAIN 2014). While costs of not having a traceability system are manifested mainly during animal disease outbreak, its impact can be enormous.

Benefits associated with a traceability system in dealing with safety and quality issues are numerous. The RFID monitors animal movement between locations and has the ability to trace an animal from birth until it is slaughtered at a butchery (Voulodimos, Patrikakis et al. 2010, Liang, Cao et al. 2015). Suppliers are able to prevent contaminated or low quality products reaching the consumers, increase consumer confidence and thus build brand loyalty (Choe, Park et al. 2009, Bibi, Guillaume et al. 2017). This way the commercial health and increased profits can be maintained (Choe, Park et al. 2009, Besbes, Hoffmann et al. 2010, Anna, Ronn et al. 2017). It is argued that "... profit obtained from producing traceable food is greater than the profit obtained from producing ordinary food (Bai and Li 2014:p45). This is because RFID provides an opportunity to reduce labour costs, decrease inventory shrinkage and increase sales through building consumer confidence (Kumari, Narsaiah et al. 2015, Lorite, Selkälä et al. 2017, Badia-Melis, Mc Carthy et al. 2018, Biswal, Jenamani et al. 2018).

2.8 The Cost Bearer Dilemma

Adoption of RFID is costly. Literature recognises that there is a tendency to expect a particular party in the supply chain to bear the cost of implementing the RFID. Normally farmers and abattoirs bear such costs. However, distributers; retailers; marketers; consumers and even government also enjoy the benefits of the RFID. For this reason, it is suggested that government must play a role. Government involvement could include incentives "... to the enterprises which implement the quality and safety traceability system of agricultural products ..." (Bai and Li 2014:p46). Governments can also take the responsibility of managing the behaviour of stakeholders in the supply chain through international conventions, internal regulations and monitoring (Bai and Li 2014).

The study of the Karoo sheep observed that the abattoir carried "... all the costs of the implementation of a traceability system while very little of the benefits befall them" (Kirsten, Jordaan et al. 2013:p79). A similar challenge was experienced among the resource poor farmers in the US (Skaggs 2011). Throughout the world, resource-poor farmers, have low incomes and would battle to implement RFID on their own (Skaggs 2011, Jenjezwa and Seethal 2014). It is for this reason that the role of government in support of these farmers is advanced. The US government invested up to $120 million of public funds in 2009 to support non-commercial farmers during the introduction of a traceability system (Skaggs 2011). Also, the government of Namibia through the Meat Board of Namibia offered subsidies to support cattle farmers comply with the NamLITS (Meat Board of Namibia 2012).

2.9 Acceptance of RFID

The introduction of NAIS in the US had to deal with two critical concerns. The first was that small-scale farmers suspected the intentions of government and believed that NAIS was being used as a false emergency to extend government control (Skaggs 2011). The second was the concerns with respect to costs and benefits of the system. It appeared that non-commercial farmers would bear additional operational costs by adopting the NAIS while other participants in the value chain reaped benefits (Skaggs 2011). Scepticism among abattoir operators in South Africa is based on the idea that all participants in the supply chain will benefit from RFID even though only a few paid for its implementation (van der Merwe 2012, Kirsten, Jordaan et al. 2013).

2.10 Animal Identification and Traceability in South Africa

Given that this study took place in South Africa, attention is paid to the animal identification system in the country. The South African beef industry has suffered from the FMD outbreak and the horsemeat scandal. It is observed that the responsibilities of government to control food safety are fragmented because of, "... a multiplicity of players resulting in overlaps and gaps, breakdown of the chain of command, lack of effective coordination and inefficient use of resources" (Department of Agriculture Forestry and Fisheries 2013:p6). Further, the lack of effective traceability as manifested through the horsemeat scandal was attributed to, "... involvement of multiple intermediaries across multiple countries in the supply chain of raw meat products, making it difficult to trace the ingredients used in the meat product" (Department of Agricculture Forestry and Fisheries 2013).

The Meat Safety Act (Act No. 40 of 2000) attempts to introduce standards in animal products in order to promote meat safety (Republic of South Africa 2002). Among others, the Act is considerate of the interest of the consumers. In terms of Section 11 (1) (0) of the Act, "the owner of an abattoir must keep the prescribed records relating to the number of animals slaughtered, the origin of animals slaughtered, details of examinations carried out while the animals were alive and inspections carried out after animals had been slaughtered and destinations of the meat and animal products, and must at the request of a person contemplated in paragraph (c) furnish such information to the person" (Republic of South Africa 2002:p6). The intention of the Meat Safety Act to promote safety standards through detailed record keeping is weakened by inability of the Animal Identification Act to provide for superior means of record keeping at the farm level. How can abattoirs keep records about the origin of animals, when such records are non-existent in the first place?

The absence of a national animal traceability system in South Africa does not suggest that there is no such capacity for the application of RFID. Traceability has been adopted on ad-hoc basis by various livestock producers and abattoirs to respond to market demands. A study conducted in the sheep industry in the Karoo showed that "... the South African sheep meat industry and its abattoirs generally have the ability to trace a meat product with their traceability systems" (Kirsten, Jordaan et al. 2013:p81).

Currently, South Africa is being monitored by the OIE in an effort to put FMD control measures in place to be fully accepted in the EU beef markets (Department of Agricculture Forestry and Fisheries 2014). During the visit of the OIE in November 2014, the Committee appeared to have been encouraged with efforts made by the South African government authority, Veterinarian Services, to control FMD (Department of Agricculture Forestry and Fisheries 2014).

2.11 Traceability in other commodities in South Africa

Discussion in Section 2.10 shows that the sheep industry and sheep abattoir have sufficient capacity to apply traceability in the supply chain. Given that the Animal Identification Act in South Africa does not regulate traceability, the existing capacity in the Karroo sheep industry has been built on voluntary basis. Traceability systems for other industries involved in consumable products in South Africa appear to be well regulated. Examples are made of the wine and fruit industries.

The work to introduce traceability in the wine industry started as early as 2003 with the establishment of the Wine Traceability Working Group to refine the GS1 standards to facilitate compliance with traceability guidelines (GS1 2008). The Wine Traceability Working Group is a global organisation to which South Africa is a participant. The purpose of GS1 is to set standards for compliance with traceability to all countries supplying wine to the European Union (GS1 2008). In the study of traceability of the South African fruit export industry, importance of adoption of traceability system was highlighted (Olivier, Fourie et al. 2006). It is anticipated that exportation of fruit to the EU by South Africa can benefit from automated supply chain with respect to efficiency and effectiveness of traceability system (Olivier, Fourie et al. 2006). In particular, the traceability of agricultural products of plant origin are regulated by the

Agricultural Product Standards Act [Act No. 119 of 1999] (Department of Agricculture Forestry and Fisheries 2007).

2.12 Risks and Limitations of RFID

The promise of RFID as a technological solution to improve animal identification and traceability is not without risks and limitations. While RFID is effective in tracking the movement of goods in the supply chain, this technology is constrained by the inability to fully protect "… any information about conditions that the product has encountered through its passage along the supply chain" (Chain and Lee 2010;p61). The ability of RFID readers can be constrained by a number of factors including: poor positioning, interference from metals or other RFID tags, the distance and the ability of the reader to activate energy from the chip (Chain and Lee 2010, Min 2010, Smiley 2015).

There are also challenges with regard to retrieval of data. It is argued that readers "… are not always able to read a chip on a 100% basis" (Min 2010:p36). Effectiveness of RFID is hampered by jamming, cloning, eavesdropping, skimming and malware (OECD 2008, Costa, Antonucci et al. 2013). RFID is subject to malicious counterfeiting attacks, lack of cooperation among different parties in the supply chain, transmission interference and cost risks (Park, Koh et al. 2010, Li and Liu 2011). In Botswana some of the challenges experienced in the implementation of the LITS included the lack of political will, limited human and financial capacity and lack of coordination among different players (Moreki, Ndubo et al. 2012).

The type of technology can also pose some limitations. For example, ear-tags may break loose from the ear (Moreki, Ndubo et al. 2012). Ear-tags are also prone to tampering and adverse temperature. The bolus has an advantage that it is less prone to tampering and as such, more secure than the external ear-tag (Moreki, Ndubo et al. 2012). The disadvantage of the bolus is that it is expensive than the ear-tag.

2.13 Conclusion

Literature reviewed for this study has shown that animal identification is an old practice which started as means to prove ownership. However, this ancient practice has since evolved to enable effective participation of beef producers in the global meat and dairy market. The fact that trading takes place at a global level means that beef production is not only a farm level matter. Trading in the global market means that production of meat and meat products must be integrated into the global market through the supply chain. It also means that there has to be a healthy network between the producer and the consumer. The outbreak of animal diseases in the past decades has made the consumer to desire more information about how the production process takes place. In response to global consumer demand and the need to maintain access to the global market, traceability systems have been integrated into animal identification. Key drivers of RIFD include farm management, supply chain management, marketing and commercial factors inevitably imposes traceability systems into the supply chain including production, distribution and marketing. In the past decades there has been a migration towards animal identification and traceability by well developed world economies. Some countries in Southern Africa have followed suit. Surprisingly, others including South Africa seem to resist this migration for reasons that are not known.

Chapter 3 Methodology

3.1 Introduction

A quantitative approach was adopted to conduct this study. Scientific research follows a rigorous design to determine appropriate instruments to collect, measure and analyse data. Research is judged on credibility, validity, reliability and the generalizability of the findings. This is achieved through minimising errors that may occur during a research exercise. This Chapter presents: research design; sampling; and data collection procedures followed in this study. The Chapter also explains and justifies how adopted research instruments contributed to the credibility, validity, reliability and generalizability to enhance the quality of study results.

3.2 Research Paradigm

There are two main paradigms for conducting research. These are quantitative and qualitative research paradigms. Both of these paradigms were considered to determine the most appropriate approach for this study. The distinction between quantitative and qualitative is with respect to sampling procedures, data collection and data measurement. The quantitative research method is predominantly positivist while the qualitative approach is predominantly phenomenological (Sekaran and Bougie 2013)

The Positivist approach works "... with an observable social reality and that the end product of such research can be the derivation of laws or law-like generalisations similar to those produced by the physical and natural scientists (Remenyi, Williams et al. 2010). On the contrary, the phenomenological approach is theoretical and assumes that '... the world can be modelled, but not necessarily in a mathematical sense. A verbal, diagrammatic, or descriptive model could be acceptable" (Remenyi, Williams et al. 2010:p34). Positivists uses statistical measurements while the phenomenological perspective relies on descriptive measurements.

3.2.1 Research Design

Research design is a "... blueprint for the collection, measurement, and analysis of data, based on the research question of the study" (Sekaran and [redacted]:p95). The overall research design ensures that the researcher is able to address the research problem successfully. The research design must be aligned to the research paradigm while being able to dictate the research strategy. Research design in terms of data collection, measurement, and analysis for this study is quantitative in nature, and thus differed from qualitative methods

3.2.2 Research Strategy

Research strategy distinguishes the research type and purpose. There are a number of research strategies that may be adopted, including: experiments, survey research, observation, and case studies. Experimental strategy relies on experimental designs with the aim to deduct causal relationship (Sekaran and Bougie 2013). Observation strategy involves watching and interpreting the attitudes and behaviour of respondents in their natural setting (Sekaran and Bougie 2013). In a case study a research may study a real life situation of an individual or a group by collecting in-depth data using multiple data collection methods (Sekaran and Bougie 2013).

Survey studies on the other hand ask respondents about opinions and factual factors (Sekaran and Bougie 2013). The survey study is based on interviewing a cross-section of respondents in the field using a questionnaire or sending questionnaires by mail (Sekaran and Bougie 2013). Among others, the reliability and strength of the study is derived from the harmony of responses provided by a cross-section of the respondents.

This study sought to establish the acceptability of RFID among livestock farmers in KZN. As a result, a survey was adopted to test their (livestock farmers) opinions and attitudes about this technology. The rural conditions, under which these livestock farmers operate, dictated that a field study be conducted, using a questionnaire to collect data.

3.2.3 Research Setting

There are two generally accepted study settings, the contrived and non-contrived setting. Non-contrived setting refers to a natural and uncontrolled environment where events proceeds normally while contrived setting refers to a controlled or artificial environment (Sekaran and Bougie 2013). Non-contrived and contrived studies refers to field and laboratory studies respectively (Sekaran and Bougie 2013). Analysing the setting of the study provide an insight to the nature and characteristics of the unit of analysis and so as the possible types of biasness. This study was conducted in an open environment classified as non-contrived research setting.

The study was conducted among livestock farmers at Machunwini and abaThembu Traditional Areas at Msinga, a deep rural are in KZN. The two areas form part of the six traditional council areas of within Msinga, these being Qamu, Mbomvu, Ngome and Mabaso (Msinga Municipality 2012). This area falls within a dual administration, a traditional system led by hereditary Chiefs or aMakhosi and a democratic system led by elected councillors. The area of Msinga extends over 2 500km² and is inhabited by a total of 177 577 people (Msinga Municipality 2012). This population is comprised of 43.44% males and 56.55% females respectively (Msinga Municipality 2012). The population of KZN is considered young with the majority aged below 35 years of age (Statistics South Africa 2011). The population of Msinga is younger compared to the provincial statistics with the majority being below 30 years of age (Statistics South Africa 2011).

The Msinga Municipality has been identified as the poorest municipality in KwaZulu-Natal and is also ranked as the poorest municipality in South Africa (Statistics South Africa 2014). In South Africa there is about 10.2 million people out of 52 million people or 20.2% of the total population living in extreme poverty (Statistics South Africa 2014). Poverty in South Africa needs to be understood in terms of the Gini coefficient, a measure of inequality. In terms of the South African Statics census, South Africa has a Gini coefficient of 0.69 (Statistics South Africa 2014). This means that reach people are getting richer while the poor people are becoming destitute.

Livestock production is an important contributor to livelihoods. Common livestock species in the area include cattle, goats, sheep, poultry, donkeys and horses (Bayer, Alckock et al. 2003). Livestock is kept for different uses including settling lobola (gift or a dowry offered by the groom to a bride's family as part of negotiations for arranging marriages); meat; hides for making traditional attire and for ploughing in the case of donkeys (Bayer, Alckock et al. 2003). Marketing of livestock is limited to the informal local market (Bayer, Alckock et al. 2003).

3.3 The Profile of the target population

The members of the population from which the sample of this study was selected are livestock farmers, forming part of isiZulu speaking community in the rural area of Msinga. The farming system is open communal grazing area. The land used as grazing area by farmers, is also used by other community members for other needs, for example collection of firewood, gathering of thatch grass, gathering of medicinal plans, and cultivation of field crops. There is thus competition for different uses on the same land.

Livestock farmers are organised around dip-tanks where they are registered members of the Dip-tank Committees. The Dip-tank Committees form Msinga Livestock Association. A dip-tank is a facility for dipping animals for protection against diseases, some of which are tick borne. Dip-tank Committees keep a list of all its members as well as the number of livestock units in the area. For the purpose of this study, the list of livestock farmers being members of Dip-tank Committees was useful to determine the number of livestock farmers in the study area. The study area (aBathembu and Mchunu) had 18 dip-tanks with a total number of 1 000 livestock farmers according to the Dip-tank register. The dip-tanks are located across the study area as demonstrated in the map in Figure 3-1 above.

3.4 Research Instruments

In keeping with the quantitative paradigm, a survey was conducted in the field using a structure questionnaire. The questionnaire was conducted by trained field workers. This Section discusses research instruments used for sampling, data collection and data analysis.

3.4.1 Sampling Design

Sampling design is concerned with the selection of units of analysis from a target population and from which data is collected (Cooper and Schindler 2008). The sampling process for this study included: pinpointing a target population; determining the sample frame; identifying sampling methods and determining the sample size (Cooper and Schindler 2008). The intention was to manage errors and biasness and to ensure that the selected sample "... represents the characteristics of the population it purports to represent" (Cooper and Schindler 2008:p376).

A sample, denoted by the symbol "*n*" is a subset of the total population, denoted by the symbol "*N*" (McCutcheon 2008, Shapiro 2008, Fowler 2009, Sekaran and Bougie 2013, Blair, Czaja et al. 2014). It is noted that "... the sample size (*n*) is chosen in order to reproduce, on a sample scale, some characteristics of the whole population (*N*) (McCutcheon 2008:p782). The population is the set of members or units about which inferences are made (Blair, Czaja et al. 2014). Technically, a sample is a miniature of the population (Blair, Czaja et al. 2014). Also, a sample is a "... model of reality, and not the reality itself" (McCutcheon 2008:p783).

The model or a miniature may not always resemble the reality. This is caused by inherent sampling error, which simply measures the distance between the "model" or "miniature" from the reality. Regarding the distance between the model and reality, it is noted that "... the less it is, the more the estimates are close to reality" (McCutcheon 2008:p783). Scientific researchers aspire for a sample that represent the target population well (Blair, Czaja et al. 2014).

3.4.2 Sampling Frame

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The sample frame defines the characteristics of a target population as "... people that have a chance to be selected, given the sampling approach that is chosen" (Fowler 2009:p19). Hall 2008, suggests that a sample frame is comprised of a complete list of known units of the population. This is a list of all members of the target population from which the sample is selected (Hall 2008, Remenyi, Williams et al. 2010, Blair, Czaja et al. 2014). A comprehensive list is ideal. However, it is accepted that while the list "... should contain all elements in the population, but oftentimes these frames do not" (Hall 2008:p790). A sample frame is therefore important as it determines the target population from which the sample is selected (Shapiro 2008, Fowler 2009).

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For the purposes of this study, the sample frame defined members of the target population as:

(i) Residents of the *aMachunu and aBathembu* Traditional Council Areas;
(ii) Livestock owners who are registered members of the Msinga Livestock Association;
(iii) Livestock owners registered with the National Register of Animal Brands;
(iv) Livestock owners who keep animals within the study area;
(v) If the original owner is late, the next of kin was recognised as the owner; and
(vi) If the owner was a migrant worker, the next of kin was recognised as the owner.

From the total population of 1 000 livestock farmers according to the Dip-Tank register, the interest of this study was to select respondents befitting the above criteria.

3.4.3 Sampling Techniques

Generally, research is conducted using either probability or nonprobability sampling techniques (Cooper and Schindler 2008, McCutcheon 2008, Remenyi, Williams et al. 2010, Sekaran and Bougie 2013). It is argued that "... probability (random) sampling and nonprobability sampling, are typical of quantitative and qualitative research respectively (McCutcheon 2008:p783).

Probability sampling gives all population members the same chance of being selected (Fowler 2009, Sekaran and Bougie 2013). This ensures that the sample is representative of the population and as such increases statistical inferences (McCutcheon 2008, Remenyi, Williams et al. 2010, Sekaran and Bougie 2013). The advantage of the probability sample is that it "... uses
5
probability-based statistical procedures such as confidence intervals and hypothesis tests, in drawing inferences about the population from which the sample was drawn" (Blair, Czaja et al. 2014:p95).

On the contrary, nonprobability sampling does not give members of the population a known chance of being selected and is arbitrary (Cooper and Schindler 2008, Blair, Czaja et al. 2014).

As such, in this approach units of analysis are "... typically selected by judgement or convenience" (Blair, Czaja et al. 2014:p90). Nonprobability sampling is prone to sampling error and biases to well-known members of the population (Remenyi, Williams et al. 2010, Blair, Czaja et al. 2014).

In probabilistic sampling, researchers may choose simple, systematic or stratified random sampling (McCutcheon 2008, Remenyi, Williams et al. 2010). The most important probabilistic sample characteristic is randomness as opposed to systematic approaches (Cooper and Schindler 2008, Sekaran and Bougie 2013, Blair, Czaja et al. 2014). In simple random sampling all elements have "... an equal chance of being selected" (Remenyi, Williams et al. 2010:p193). It ensures that elements are selected from a sample frame only once and are "... independent of one another and without replacement; once a unit is selected, it has no further chance to be selected" (Fowler 2009:p24).

There are rules for calculating probability of selection where "... each population member has a $\frac{1}{N}$ chance of being selected for the sample on any given draw" (Blair, Czaja et al. 2014:p92). The formula for calculating probability is therefore:

$$\text{Probability of slection} = \frac{Sample\ size}{population\ size} = \frac{n}{N}$$

In the case of this study where N = 1000, as discussed above, the probability for any member of the population to be selected was as follows:

$$\text{Probability of slection} = \frac{1}{1000} = 0.001\ or\ 0.1\%$$

All members of the population had an equal probability of 0.1%. To ascertain fair representation, simple random sampling was adopted. This approach ensured that all elements had an equal chance, sampling error was managed and that the results would be generalizable.

3.4.4 Data gathering methods

In quantitative design, a questionnaire is the most useful tool for data collection (Trobia 2008). A questionnaire can be self-administered or interviewer-administered. Advantages and disadvantages of both approaches were considered. A self-administered questionnaire relies on mail and internet services (Lavrakas 2008). The advantage of interviewer-administered questionnaire is that there is an opportunity to introduce the research topic, clarify questions and collect responses promptly (Sekaran and Bougie 2013). The disadvantage is that the interviewer may "... introduce bias by explaining questions differently to different people ..." (Sekaran and Bougie 2013:p147). In contrast, the advantage of the self-administered questionnaire is that it can cover a large geographical area, it is comparably cost effective and that they are completed at interviewees' convenience (Sekaran and Bougie 2013). The main disadvantage is that since this approach is reliant on in telecommunications and mails, it is not applicable to areas where there is no telecommunication infrastructure. Self-administered questionnaire does not provide an opportunity for clarification of questions and tends to have low response rates (Sekaran and Bougie 2013).

Given the lack of telecommunication infrastructure in the study area; high levels of illiteracy and the vastness of the area, the interviewer-administered approach was adopted. To enhance the effectiveness of the questionnaire, a number of design elements were considered including the wording, length of questions and coding. Questions were worded in the simplest manner possible to avoid ambiguity. Questions were also designed to be short in order to avoid carrying more than one idea. Categorisation and coding of responses avoided overlaps in between responses.

3.4.5 Gaining entry into the study area

Before data was collected gaining entry in to the study areas as well as dealing with gate keeping issues were considered. The researcher visited the area to introduce the purpose of the study to farmers during one of the meetings that Msinga Livestock Association holds on a regular basis. This meeting was held at Mthembu Traditional Council. The main purpose of this visit was to seek entry into the study area and cooperation of the farmers. During this meeting, it was explained to farmers that data would be collected by field workers who would visit farmers in their homesteads.

The second visit was aimed at contracting and training field workers on data collection. After the training, questionnaires which had been translated into isiZulu, where distributed to the field workers. This was followed by field workers randomly visiting individual farmers and completing the questionnaires. Once completed, the researcher collected all questionnaires from the field workers, and a process of capturing using SPSS commenced. This was followed by an analysis of data and incorporating findings into report writing.

3.5 Research Validity and Reliability

The confidence of research findings is influenced among others by quality and goodness of research instruments. This refers to the assessment whether all instruments used to collect and measure variables have enhanced the accuracy and scientific quality of the results (Sekaran and Bougie 2013). Two items are often considered to assess the goodness of measure, the validity and reliability of data gathering and measurement instruments.

3.5.1 Validity

Validity deals the ability and effectiveness of instruments to measure variable it is designed to measure (Sekaran and Bougie 2013). The validity of research instrument is also referred to as "goodness of measure". Validity in research is important as it contributes towards the reliability of the outcome of the study.

Three types of validity are distinguished. They include content validity, criterion-related validity and construct validity. Content validity deals with how well the dimensions or sets represents the universe being tested (Sekaran and Bougie 2013). Criterion-related validity is concerned with the ability of the measure to differentiate sets into criterion it seeks to measure (Sekaran and Bougie 2013). Lastly, the construct validity deals with how well the measure produces results that fit the theories it intends to measure (Sekaran and Bougie 2013).

3.5.2 Reliability

Reliability of instruments refers to the extent to which they are able to eliminate error and biasness (Sekaran and Bougie 2013). The research instrument must be able to produce consistent result. The outcome of the study is said to be reliable when there is when biasness and errors have been eliminated. Key elements of reliability include stability of measure over time, when the repetition of measure produce the same results and when responses from two comparable measures are highly correlated (Sekaran and Bougie 2013)

3.6 Elimination of Bias

The quality of research findings also depends on the ability to eliminate and manage biasness. There are two main areas where biasness may occur. Biasness may occur during sample, selection and sampling bias, or during data collection, non-sampling bias.

3.6.1 Selection and Sampling Bias

During sample design for this study, it became crucial to mitigate for three inherent challenges, including: sample error; sample bias; and non-sample error. Sample error is defined as a "... random variation from the true characteristics of the population" (Fowler 2009:p13). Sampling error occurs when the sample does not reflect a population's true characteristics (Cooper and Schindler 2008, Blair, Czaja et al. 2014). It results from the fact that by chance as opposed to methodological design a "... sample can and will differ slightly from what it would look like if it perfectly mirrored the distribution of characteristics in the population" (Fowler 2009:p13).

The problem of sample bias indicates that a sample differs in character from the units or members of the population. Simply put, this means that "...in some systematic way the people responding to a survey are different from the target population as a whole" (Blair, Czaja et al. 2014:p11). Two types of sample bias are discussed. The first is coverage bias, which occurs when "... some segment of the population is improperly excluded from consideration in the sample ..." (Blair, Czaja et al. 2014:p13). The problem of coverage may cause under-coverage or over-coverage. Note that "under-coverage means that some members of the universe are neither on the frame nor represented on it. Over-coverage means that some elements on the frame are not members of the universe" (Hall 2008:p971). In brief over-coverage or under-coverage occurs when "... some population groups are given disproportionately high or low chances of selection (Blair, Czaja et al. 2014:p14).

3.6.2 Non-sampling bias

The last problem related to sampling is the non-sampling error. This type of an error occurs in the field during data collection. Non-sampling error occurs due to errors on the part of the interviewer or interviewee (Blair, Czaja et al. 2014). It includes the "... interviewer error related to the administration of the survey, response error related to the accuracy of responses as given, and coding error related to the accuracy of response as recorded" (Blair, Czaja et al. 2014:p14).

To eliminate sample errors and biases, the following steps were taken during the research design:

(iv) The problem of coverage was addressed through properly defining the target population prior to drawing a sample;

(v) Characteristics of the members of the population were contextualised within a sample frame to address sample error and sample biases. A sample frame is presented in Section 3.4.2 above; and

(vi) Field workers were trained to equip them in managing the problems associated with non-sampling error.

3.6.3 Ethical stance and consideration

Another important aspect of conducting research is the compliance with ethical principles. Research ethics refers to a particular code of conduct ensuring that respondents participate voluntarily and that are not exposed to physical, emotional and psychological harm or danger (Sekaran and Bougie 2013). Ethical consideration is managed in all research steps including designing the questionnaire, data collection and ensuring confidentiality during data analysis. Further, during data gathering, respondents participated voluntarily and reserved the right to withdraw at any stage of the interview.

3.7 Conclusion

Research procedures considered in this study included: positivist and phenomenologist way of thinking, quantitative versus qualitative approach; probability versus nonprobability sampling and data gathering procedures. Decisions to choose research instruments considered advantages and disadvantages and appropriateness of such instruments to this study. In the final analysis, this study adopted a quantitative approach, random sampling and a questionnaire. Based on a sample frame, sample size formulae, data was collected from 170 participants in the area of Msinga with the help of 25 field workers. All steps used in this study contributed in minimising sample error and sample biases with a view to enhance the credibility, reliability, quality and generalizability of the results.

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Chapter 4 Presentation of findings

4.1 Introduction

This Chapter presents research findings. A detailed analysis and discussions of these findings follows in Chapter 5. Data was collected from 170 research respondents, captured and analysed using SPSS. Once captured, observations were measured on Likert Scale. In accordance with the quantitative approach, research findings where summarised statistically. Reporting on findings focuses only on observations with significant statistical values. This Chapter is divided into the following sections:

i. Respondents' demographic profile;
ii. Herd size of animals;
iii. Methods of animal identification;
iv. Effectiveness of current animal identification methods;
v. Acceptability of RFID; and
vi. Perceptions RIFD benefits.

4.1.1 Demographic profile

This section describes the profile of respondents based on research findings. The demographic profile gives insight regarding the characteristics of respondents which may influence their behaviour and attitude towards both livestock production, animal identification and perceptions about RFID. For the purpose of the study, key characteristics of the respondents include gender, age, education and income. Also, the level of respondent's dependants was considered to get a sense of the financial responsibilities.

4.1.1.1 Gender

Figure 4-1 shows that the gender of the livestock farmers who participated in this research is 25% to 75% females and males respectively.

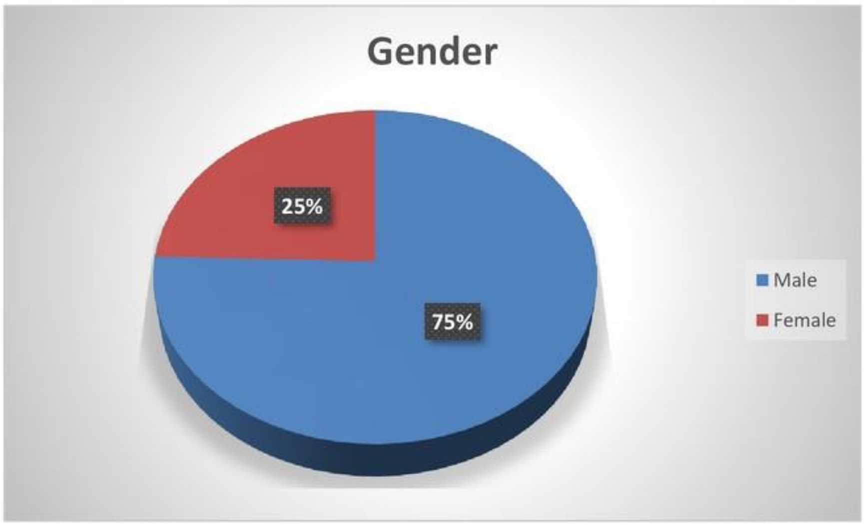

Figure 4-1: Gender of livestock farmers

The gender distribution further indicates that the ownership of livestock, which is regarded as an important means of production in Msinga, is dominated by the male livestock farmers. This finding confirms inequality between male and female with respect to livestock ownership.

4.1.1.2 Age

The interest of the study was to establish the age distributed pattern regarding livestock ownership. The ownership of livestock based on age distribution shows that young people below the age of 40 years, share a total of 19% of ownership. Livestock ownership is concentrated to the age bracket ranging from above 41 to above 61 years of age respectively. The study found that the age bracket 41 to 50 years owned 20%, 51 to 60 years of age owned 24% while 60 years and above owned 36.2 %. In summary the age distribution shows livestock ownership is concentrated in the hands of older people as opposed to the youth.

Figure 4-2: Livestock ownership by age pattern

A further step was taken to analyse ownership of livestock by gender and by age. A similar pattern is observed between the 25% female and 75% male livestock farmers in terms of ownership. Figure 4-3 below confirms that there are more males owning livestock than females. Also, the diagram shows that the distribution pattern between female and male farmers is similar in ownership is concentrated to the older members of the population

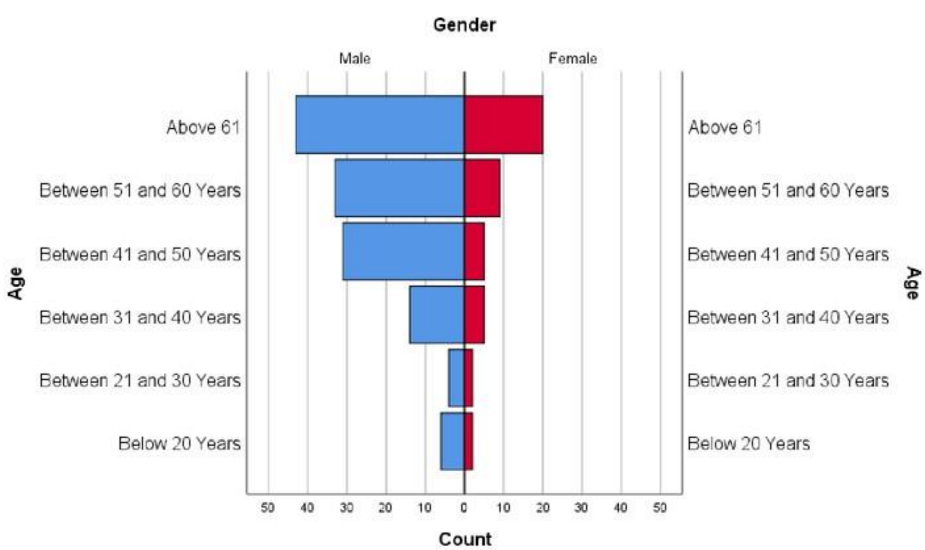

Figure 4-3: Livestock ownership by age and gender

4.1.1.3 Education and training

The assumption is that the level of education could influence the perceptions of the respondents about farming practices, and in particular their understanding of technology such as RFID. Figure 4-4 shows high level of illiteracy among the livestock farmers at Msinga. At least, 55% of respondents had no formal education whilst the level of education for at least 38% was below Grade 12. Only 4% of the respondents had reached Grade 12 while only 1% had college

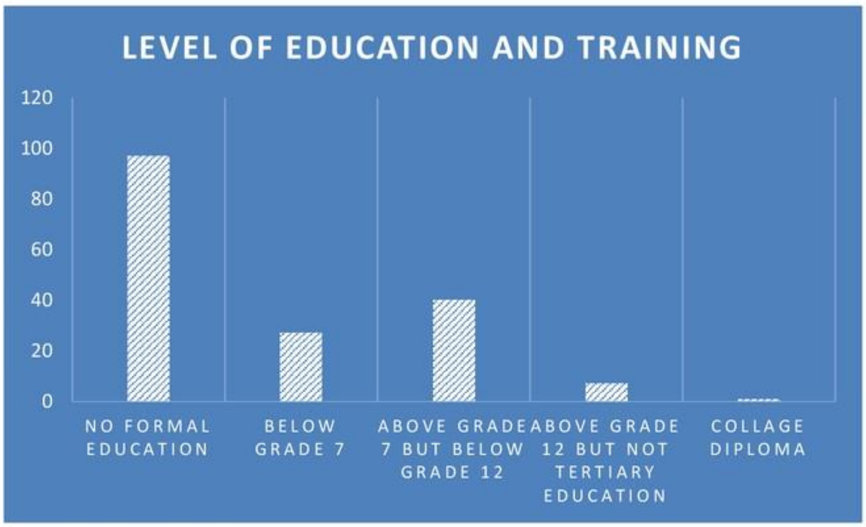

Figure 4-4: Level of education and training

education.

4.1.1.4 Income

The question of monthly income of the respondents sought to understand two things. The first was to determine whether livestock farmers have had alternative source of income or they that they solely dependent on livestock production for survival. Secondly, the study sought to test whether, the livestock farmers had income to invest in livestock management practices such as vaccines and adoption of RFID. Figure 4-5 below shows that 48.5 % have income of less than R1000.00 per month while 42.7% earned less than R3 500.00 per month. A very small percentage of the respondents earn above R3 501.00 per month. It is observed that the livestock farmers at Msinga fall under the category of low-income earners. It may also be assumed that the 48% of the population earning less than R1000.00 might be the beneficiaries of the government social security system. However, this may not be confirmed as it did not form part of the question of this study.

Figure 4-5: Monthly income

4.1.1.5 Dependants

Dependents are generally the members of the household that each respondent is responsible for their bringing. Such responsibility may include clothing, feeding, education and health related matters. The study found that only 9% of the respondents reported that they did not have dependents. At least 23.4% had less than 4 dependents. The majority of the respondents, 34.3% and 30.9% had more than 4 but less than eight and more than eight respondents respectively. The majority of the respondents have large number of respondents or family members to look after. Taking into account the level of education as well as monthly income, the observation is made that the respondents a huge burden with limited resources to meet the demand.

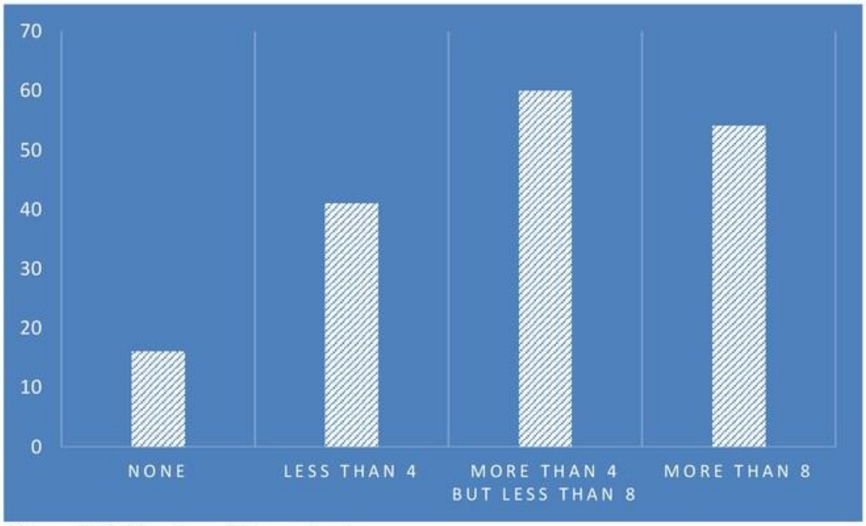

Figure 4-6: Number of dependents

4.1.2 The size of herds kept

The size of the herd kept by farmers was explored to determine the significance of livestock in the study area. The question covered different livestock including cattle, goats, sheep, horses, donkeys and pigs. Of these animals, it was found that goats, cattle and sheep are the mostly kept animals in the order of number of farmers who keep such animals. The results of the study showed that horses, donkeys and pigs are kept by few farmers and in very small numbers compared to the first three types.

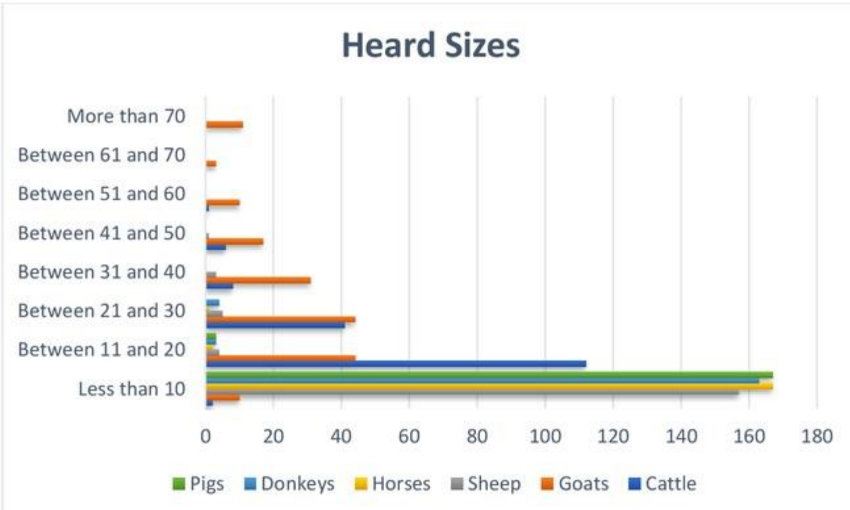

Figure 4-7 Ownership of different types of livestock

Ownership of goats ranged from 6% of farmers owning less than 10 goats; 52% owning between 11 and 50 goats; and at least 30% owning up to 60 goats. A small percentage of farmers, 5 % owned up to 70 goats.

Regarding cattle, only 1.2% of farmers own less than 10 cattle. The majority, 66% and 24% range from 11 to 20; and 21 to 30 cattle in terms of ownership respectively. Smaller percentages, 5% and 4% range from 41 to 50 and 51 to 60 in ownership of cattle respectively. Compared to goats, on average, farmers own lesser number of cattle.

With respect to sheep ownership 92% of farmers owning less than 10 sheep. The rest of farmers, which is in the minority, own between 11 and 20 sheep. Compared to goats and cattle, there were fewer livestock farmers keeping sheep.

The ownership of horses, donkeys and pigs was limited to very few farmers. It was found that 98% of farmers owned less than 10 horses; 96.4% owned less than 10 donkeys and 98% owned less than 10 pigs.

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Based on the findings of the study, an assumption is made that the most commonly kept animals are cattle, goats and sheep than they do on horses, donkeys and pigs. It is further assumed that these animals are valuable with respect to contributing to livelihood.

4.1.3 Methods of Animal identification

The interest of the study was to first establish the current animal identification by livestock farmers even before testing whether RFID would be accepted. Different methods of animal identification were tested. These include, naming animals, identification of animals by skin colour, using unauthorised brandmarks, using authorised brandmarks as well as combining different methods of animal identification. Figure 4.8 below presents the finding of the study on the question of animal identification.

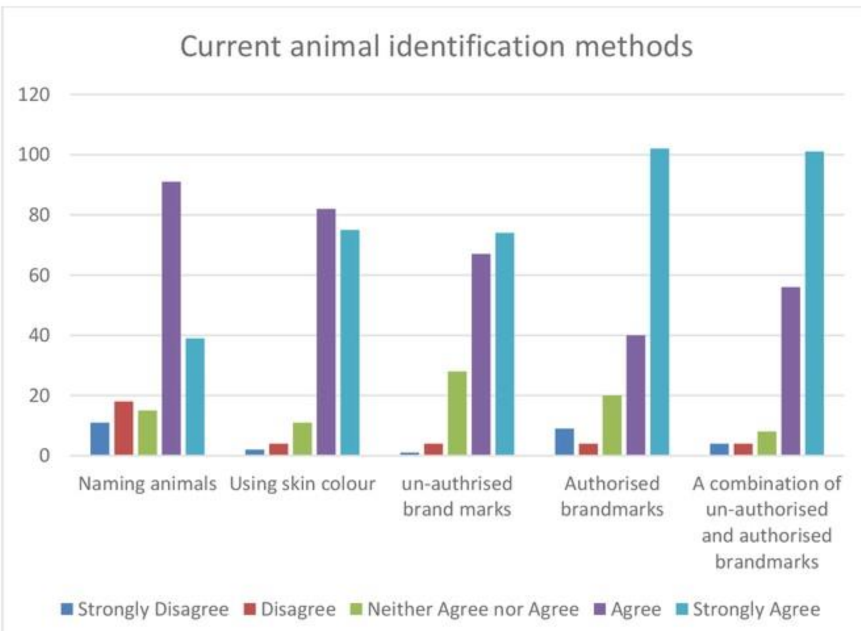

Figure 4-8 Distribution of different methods of animal identification

i. **Identification by naming animals:** The study found that at least 74.3% of the respondents identified animals by giving them names. A total of 17% did not agree with the practice of naming animals while at least 9% neither agreed nor agreed with this practice.

ii. **Identification of animals by skin colour:** The study findings showed that another form of animal identification was the use of skin colour. The majority of respondents indicated that they used the colour of the skin to identify their animals. A total of 46.9% agreed with this method of identification while 42.9% strongly agreed with this method. Only 10.3% of respondents did not agree with the use of this method of animal.

iii. **Animal identification using un-authorised brandmarks:** A total of 81% agreed with the sentiment that livestock farmers use un-authorised brandmarks to identify their animals. This percentage constitute 38.5% of respondents who agreed with this sentiment and the 42.5% who strongly agreed. Only 3% of the respondents did not agree that un-authorised brandmarks are used to identify animals.

iv. **Animal identification using authorised brandmarks:** Respondents who indicated that livestock farmers identify animals using authorised brandmarks were 81% while those that responded otherwise were 7.4%. There was 11.4% who were neutral to this question.

v. **Animal identification using the combination of un-authorised and authorised brandmarks:** The study also tested the use a combination of both un-authorised and authorised identification methods. It was found that 90% of the respondents responded that livestock farmers use both un-authorised and authorised animal identification methods, with 5% disagreeing with this approach and another 5% being neutral to the question.

There are several practices of animal identification currently being applied by farmers in the study area. The findings of the study show that livestock farmers do not rely on a single method for animal identification but a combination of multiple methods. In legislation, there is only one recognised animal identification method, that is, the authorised animal identification issued by the relevant authority, Animal Registrar. Other animal identification methods, in particular the un-authorised brandmarks, are randomly developed by livestock farmers as desperate means to enhance a sense of ownership.

4.1.4 Effectiveness of current animal identification methods (branding methods)

The study sought to establish the perception of livestock farmers regarding the effectiveness of the current animal identification methods, in particular branding methods. The idea was to test whether the current animal identification is effective with respect to keeping animal records, whether the current methods support traceability and whether animal records could be readily available on request. Figure 4.9 presents the finds of the study regarding effectiveness of the current animal identification methods.

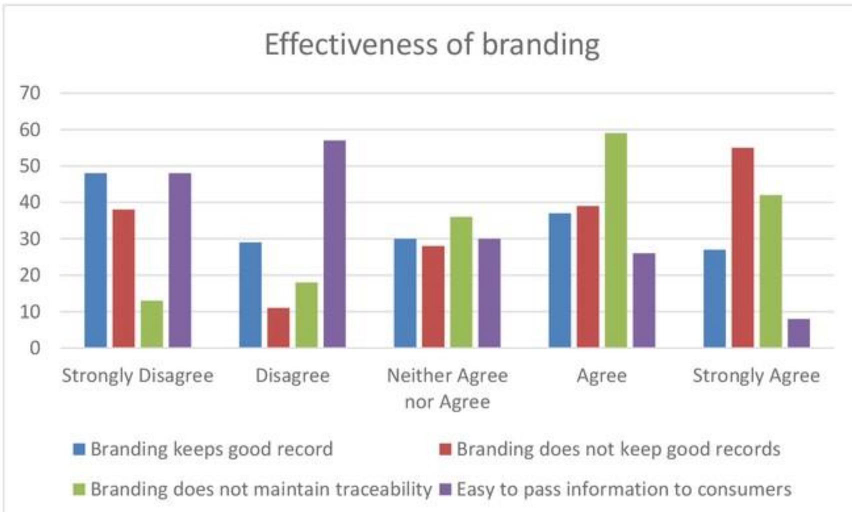

Figure 4-9: Effectiveness of current animal identification methods

The findings of the study with respect to the effectiveness of the current animal identification methods are summarised as follows:

i. **Branding keeps good records:** At least 60% of the respondents disagreed with this sentiment while only 17% believed that branding help farmers to keep good records.
ii. **Branding does not keep good records:** 55% of the respondents agreed that branding does not keep good records while 28% disagreed with this sentiment.
iii. **Branding does not maintain traceability:** At most 60% of the respondents agreed that branding is not capable of maintaining traceability while 18.5% thought that it does with 21% feeling neutral about the question.

iv. **Branding makes it easy to pass information to the consumers:** 20% of the respondents believed that branding allows for easy transfer of information about animal products to customers while 60% did not think that this was possible.

A number of different questions were asked in both passive and active form to test the effectiveness of the current animal branding system. In summary, it was found the current animal branding is not effective to keep animal records and does not support traceability.

4.1.5 Acceptability of RFID

The study tested whether respondents thought that farmers in the area will accept RFID as a tool to enhance a sense of ownership. Data was collected to reflect an indication of the number of farmers that both through that (i) farmers will not accept RFID; and those that thought (ii) farmers will accept RFID. Figure 4-10 below presents the findings to this question.

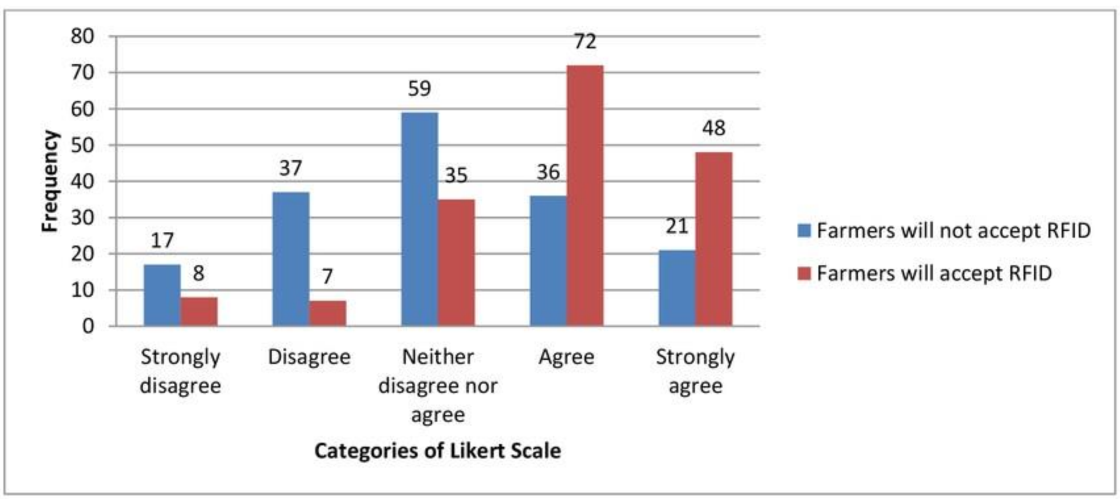

Figure 4-10: Acceptability of RFID

At most, 71% of respondents thought that farmers will accept RFID, of these, 42.35% agreed while 28.23% strongly agreed with this sentiment. Only 32% of respondents thought that this technology will not be acceptable.

4.1.6 Perceived benefits of RFID

The study sought to understand the reasons for both acceptability of RFID or lack of it thereof. Four different types of benefits were considered. They include enhancement of consumer confidence, improvement of animal records, diseases surveillance and improvement of breeding and selection. Figure 4.11 below present the responses.

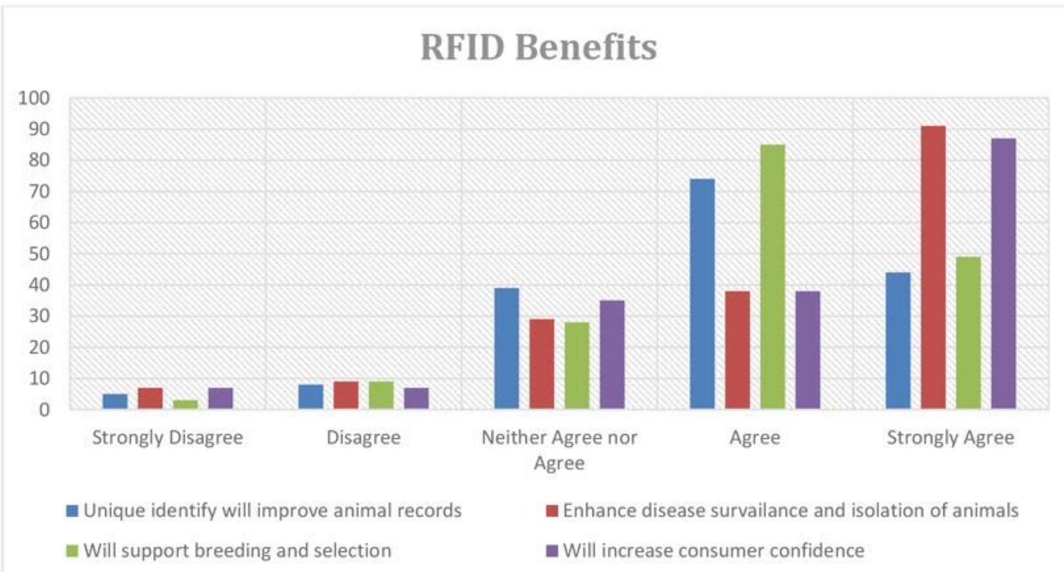

Figure 4-11: Perceptions about why RFID will be acceptable

The perceived benefits of RFID can be summarised as follows:

i. **Enhancement of consumer confidence:** The majority of respondents, 71.8%, thought that improved animal traceability will help build consumer confidence. This constitute 21.8% of respondents who agreed and 50% of respondents who strongly agreed with this sentiment. Only 8% did not while 20.1% the respondents were neutral.

ii. **Improvement of animal records:** The majority of respondents, 69% believed that RFID will improve the upkeep of animal records while only 7.6% believed otherwise, with 22.8% being neutral to the question.

iii. **Disease surveillance:** At most, 74% of respondents believed that RFID will improve monitoring of animal health and disease surveillance, 9.2% did not think so while 16.7% were neutral.

iv. **Support breeding and selection:** With respect to animal breeding and selection, 77% of the respondents believed that RFID will have positive benefits while 6.9% did not perceive this benefit and 16% remaining neutral to this sentiment.

In summary, the respondents believed that RFID will improve animal identification to support both production management practices as well as increase consumer confidence.

4.2 Conclusion

In conclusion, the following aspects are highlighted. Livestock production has the potential to contribute to livelihoods and alleviate poverty caused by high unemployment and low monthly income. As a result, securing a sense of ownership of animals through different methods of animal identification is important to farmers. Animal identification in the study area is applied through a dual approach of authorised and unauthorised systems. The dual approach is seen as a way of strengthening a sense of ownership. None of these two systems are fully effective with regard to the traceability of animals and animal products. The Animal Identification Act (Act No. 6 of 2002) does not have provision for traceability and as such, is also not useful in this regard. To change this situation, it is clear that RFID can play a significant role. Among others, respondents were of perceptions that RFID could improve livestock production and management, improve traceability of products and thus help build consumer confidence. It is understood that costs could become a bearer on the implementation of RFID, but nevertheless, the majority of respondents believed that farmers would accept this new technology.

Chapter 5 Discussion

5.1 Introduction

This Chapter interprets the study findings to make sense of the current animal identification practices at Msinga. The interpretation is based on both the current animal identification system in South Africa and global practices. To test whether RFID will be acceptable as an information technology solution to enhance animal identification and traceability, this Chapter constructs a theoretical framework as a measure of this inference. Chapter 6 relies on this theoretical construct to make inference and recommendations. This Chapter also reflects on the three objectives of this study as presented in Chapter 1, that is: understanding the current animal identification and traceability systems among communal farmers; effectiveness of the current animal identification on traceability of meat products; and testing farmers' willingness to accept RFID as a solution to improve the animal identification and traceability system. Lastly, this Chapter applies Chi-Square to test the hypothesis of this study, "Ho" and "H_1".

5.2 Theoretical Constructs for Animal Identification and Traceability System

One of the outcomes of a positivist research, is the derivation of "law-like" generalisations, or some theoretical constructs to measure observations (Remenyi, Williams et al. 2010). This section achieves this by developing theoretical constructs, an animal identification toolkit, redefining environments within which RFID operations and lastly, redefining a philosophy of "farm-to-fork" and "fork-to-farm".

Radiofrequency identification is based on information technology with at least two important dimensions. The first dimension of RFID is visual and tangible, while the second is neither tangible nor always visual. The RFID infrastructure such as an ear-tag and scanners form part of the tangible dimension and therefore can both be seen and touched. The software system of the RIFD such as the server form part of the intangible dimension and therefore can neither be seen nor touched. This is because in as much as a data sever is materialistic, it can also take the form of cloud computing. In this case, data is saved in a "cloud" and can only be accessed and downloaded on to users' computers or devices only when required.

Based on the literature review and data analysis three theoretical constructs are suggested. These theoretical constructs are: the understanding of RFID enablers; environmental dimensions and the "Farm-to-Fork" and "Fork-to-Farm" concept. Because RFID is by its nature a complex technology, there is a need to develop some measures to determine the existence and effectiveness of this system. Without any objective measure, the effort to understand the existence and effectiveness of traceability system remains difficult. These theoretical constructs therefore serve to form the basis for measuring the existence and effectiveness of RIFD.

5.2.1 Enablers of Radiofrequency Identification

In Chapter 2, reference was made to a number of factors prompting the need for RFID. These factors also make assumptions that particular conditions must be in place justifying the need for RFID. There are also particular requirements to be met for this technology to be functional and effective, otherwise referred to in this study as RFID enablers. It is recognised that a list of such enablers can be infinite. For the purpose of this study, six important RFID enablers were identified. They are:

i. Demand or motivation for RFID technology;
ii. Guidelines, standards and legislation;
iii. Availability, acceptance and affordability of the technology;
iv. Availability of RFID technical information;
v. Cooperation of key players in the supply chain; and
vi. Proper design and implementation of RFID.

5.2.1.1 Demand and Motivation for Radiofrequency Enablers

Chapter 2 discussed and presented evidence for demand and motivational factors for RFID. These factors are categorised into two, pull and push factors. Pull factors stem from the market and serves as incentive for producers to adhere to requirements for traceability and food quality standards. Chapter 2 also demonstrated that good response to pull and push factors triggers are compensated through profits and competitive advantage. Conversely, non-response to pull and push factors also attracts a particular outcome. The poor response and low uptake of RFID create a barrier to international premium beef markets.

Pull factors can be divided into three: consumer demand, product differentiation and requirements for supply chain efficiencies. All these three can be defined in one universal language well understood by the global corporate world; that is, increased market shares through product differentiation, increased profits margin and competitive advantage. Consumers are an incredibly influential stakeholder at the market, especially as they increasingly become aware of food incidents resulting from animal diseases as well as contamination during production and distribution of products. Due to increasing awareness, consumers continue to demand assurance on food quality and safety. The best way to provide this assurance is through traceability. There is sufficient evidence presented in Chapter 2 suggesting that many countries and particularly in first world economies, have responded to the pull factor and adopted traceability systems to guarantee food safety to customers. Once a piece of meat is in a plate at a "dinner table" hundreds if not thousands of kilometres from the place of origin, customers want to be satisfied that should a need arise, the product must be easily tracked from "plate to farm". Existing literature has demonstrated that adoption of traceability is associated with economic gains. This is simply because guaranteed traceability of products is a way of gaining access to international markets and attracting premium prices in return for safe food. Also, pull factors are associated with improvement of supply chain efficiencies. Traceability of products through supply chain means that companies are able to manage inventories in transit by determining the exact location on real time basis. This way planning, decision making and guaranteeing delivery dates are made easy. Also, management of inventory in transit reduces labour time; controls inventory shrinkages and assists to detect contamination of food and improve call-back turn-around time. Efficiencies in supply chain management reduce operational costs and contribute to financial gains.

In contrast, push factors do not occur at the market, but the point of origin. Like pull factors, push factors also require producers to operate in a particular manner. Different push factors my include animal diseases outbreak, stock-theft and the need to improve the breed through breeding and selection.

Animal disease outbreaks are regarded as push factors, compelling producers to consider new management approaches. Countries that have been affected by animal disease outbreaks and as a result have been banned to export meat products to international markets, have adopted RFID as production management tool. RFID has been adopted in these cases for its ability to isolate affected animals, putting in place future animal disease surveillance and effecting traceability. In terms of empirical evidence discussed in Chapter 2, South Africa has suffered from a number of animal disease outbreaks.

In the case of Msinga, the respondents highlighted stock-theft as one of the reason why RFID is required. There was also indication that RFID could enhance the management of breeding and selection. These are the factors at a production level that forces the farmers to improve traceability through technology such as RFID.

5.2.1.2 Guidelines, Quality Standards and Legislation

There are a number of international guidelines available to provide support towards the implementation of RIFD. Without such guidelines, individual countries would more than likely implement RFID based on domestically oriented frameworks which would not be compatible at a global level. There would be a mismatch of technology and it would not achieve any purpose. It is important therefore that there is as close to universal as possible set of guidelines and frameworks for implementation of RIFD.

There are sufficient guidelines for the implementation of RFID developed by well recognised international organisations with interest on product quality and safety during livestock production. Existing guidelines can be viewed from two dimensions, some pertaining to animal identification and traceability and others to RFID technology standards. As discussed in Chapter 2, guidelines pertaining to animal identification and traceability have been produced by OIE, ICAR, WTO and FAOU while guidelines pertaining to technology standards have been developed by ISO.

In addition to international guidelines and quality standards, respective countries embarking on implementation of RFID tend to pass relevant legislation to support this. Such legislative framework clarifies roles and responsibilities of different stakeholders. Legislation also clarifies as to whether RFID is treated as a voluntary or mandatory practice. Lastly and perhaps the most importantly, legislative framework also addresses the approach for implementation. Most countries have dealt with this concern by establishing a designated authority to become a custodian of RFID, its implementation as well as dealing with storage and use of data.

5.2.1.3 Designated Authority

Countries that have adopted RFID have done so under the auspices of an established designated authority. Such an authority becomes responsible for the design and implementation of the technology. One of the risky area of the traceability system is ensuring that data is secured. This also becomes an important function of a designated authority. In the case of the current animal identification system in South Africa, there exists the Registrar of Animal Brands. Currently, this authority deals with animal identification using brand marks and not RFID. Custodianship of the traceability function could reasonably be an added function to this body.

5.2.1.4 Availability and Affordability of RFID

Chapter 2 demonstrated that RFID has been in existence for decades. Over this period, this technology has been improved and perfected alongside the advancement of information technology in general. RFID is also available in different types geared for different purposes. This provides options for selecting the most appropriate technology to suit the need. Availability of RFID in different types provide options to countries planning to adopt this technology.

While the availability of RFID is not a limiting factor, costs may be. Literature in Chapter 2 suggested that implementation costs may be a limiting factor. Chapter 2 also demonstrated that the consensus regarding who should bear the cost is not easily reached. This is due to the fact that benefits of this technology are shared by all stakeholders in the supply chain. Various ways of dealing with implementation costs have been discussed thoroughly in Chapter 2. This dimension is also discussed in Chapter 6. It is suffice in this section to suggest that a solution to cost as a bearer to the implementation of RFID can be found.

The study found that the livestock farmers at Msinga are low-income earners living in an area regarded as one of the poorest municipality in South Africa. Clearly, affordability of implementing and maintaining the RFID does not exist. Also, the study found that there was a high level of illiteracy among the livestock farmers. By its nature, the utilisation of RIFD requires technical expertise. Livestock farmers at Msinga would rely on a third party, mostly lively government for subsidies and technical support for effective implementation and use of RFID.

5.2.1.5 Cooperation of Key Players in the Supply Chain

Effective implementation of RFID relies on cooperation of all role players in the supply chain. In the case of livestock, these include suppliers of feed, suppliers of medicines and vaccines, livestock producers, abattoirs, distributors, marketing agents and retail shops. All these stakeholders need to design their systems in a manner that it is compatible to each other thus forming an integrated network of supply chain. This also ensures that stakeholders are able to interconnect and interact with one another to serve mutual interests and needs. Further, the need for compatible technology ensures that information is transferred from one stakeholder to another with ease, for example, from livestock producers to abattoirs. Disintegrated technology would mean that transfer of data is disrupted.

The stakeholders that Msinga livestock would require cooperation form include the suppliers of feed and medicines on the one had and the markets on the other hand. Providers of extension service and training, which would include government and private sector presents another area that requires stakeholder cooperation.

5.2.1.6 Proper Design and Implementation of RFID

Once a potential user or country has decided to adopt RFID, the next most important stage is design. This stage ensures that the user is able to identify suitable technology based on interest and needs. This will also take into account existing guidelines, quality standards and legislation as well as the type of technology already incorporated into the supply chain. Also, it is important to consider advantages and disadvantages of different RFIDs in order to identify a superior, cost effective and is most effective type. The other important factor during the design stage is to plan for all important three dimensions of RIFD, that is ear-tags, responders and data server. Planning for one out of three, or even two out three would merely be a waste of effort, time and resources. It is strongly suggested therefore that implementation of RFID should not be commissioned if anyone of the three dimensions is not in place.

5.2.1.7 Overview of a Checklist of Radiofrequency Identification Enablers

Based on the 6 (six) enabling factors discussed above, this study developed a toolkit that can be used to determine two factors. The first is to determine whether conditions are favourable for the implementation of RFID. Secondly, once enabling factors have been satisfied, the toolkit can be used to test necessary conditions for RFID to be effective. This toolkit is represented in Table 5-1 below. The toolkit was applied to the situation of Msinga in particular and South Africa in general to test whether conditions are favourable for adoption of RFID based on the observations during the study. Enablers for RFID were first listed and corresponding indicators were identified to determine the status of each in relation to South Africa. The application of the toolkit based on literature review and research findings suggests that some enablers to support RFID are already in place even in the case of South Africa. Others are not, but can be addressed. For example, given the situation of FMD the demand for RFID exists. Also, international guidelines and RFID technology already exist. The application of this toolkit shows that two critical enablers for RFID, domestic legislation and a designated authority do not seem to exist. There are two other elements which are non-existent; the level of affordability and cooperation of stakeholders. However, these can easily be overcome. In particular, the availability of funds and stakeholder cooperation can be addressed through legislation and existence of designated authority.

Table 5-1: Checklist for RFID conditions

Condition	Indicators
Demand for RFID	In the case of South Africa, both "push and pull" factors places compelling demand domestically and internationally
Guidelines and Legislation	Internationally, there are sufficient guidelines and standards. This study could not find evidence suggesting that South Africa has necessary legislation to support livestock identification and traceability
RFID availability and affordability	Advanced technology is available in South Africa. However, poor resource farmers such as at Msinga may not afford, but this condition could be met through government support.
Designated Authority	This study could not find any evidence suggesting that South Africa has a designated authority responsible for livestock identification and the traceability system.
RFID design	Countries that have adopted RFID invested time and resources designing a programme of traceability.
Cooperation of stakeholders	There would not be proper stakeholder cooperation unless there is a legislative framework for such. However, stakeholder cooperation could be negotiated with success.

Based on the toolkit, it is concluded that in spite of the demand and benefits of RFID, livestock identification and traceability key enablers at Msinga and South Africa as whole generally does not exist.

5.2.2 Environmental Influences on Animal Production and Identification

Animal identification is influenced by three levels of environmental factors. When dissected, it becomes apparent that animal production and animal identification is influenced by local, national and global environmental factors. Figure 5-1 below depicts influences of environmental factors to animal production and animal identification. The discussion below demonstrates the impact of these environmental factors and possible measures that farmers can put in place.

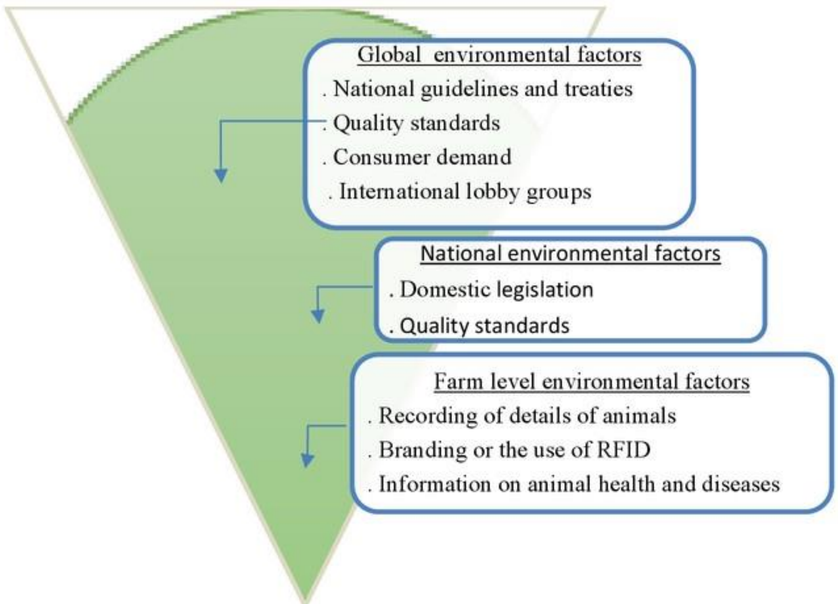

Figure 5-1: Animal identification environmental influences

Local environmental factors include farmers' responsibility to keep records of animals as part of production management. Animal records kept are with respect to feeding, animal health, disease surveillance, treatment of diseases, records of animals born on farm or bought from other farms as well as records relating to medication and vaccinations. Central to keeping all necessary animal records is proper animal identification. Traceability can enhance animal records, data storage and retrieval. The main purpose of keeping animal records is to ensure food quality and safety. The process of keeping records also involves recording of all inputs and ingredients used during production including information of their sources. The local environment is narrow in scope and impact and as such, it is relatively manageable and easy to manipulate.

National environment refers to factors that do not only affect an individual farmer but a large number of farmers in the beef industry as a whole. This environment is intermediate but broader in scope compared to the local environment. It includes domestic legislation on matters relating to animal production and identification. Apart from legislation, there are market and supply chain requirements to be complied with. Domestic customers, especially the high-income earners and the health-conscious market, tend to exert a demand regarding food quality and safety.

Because the national environment is broader than the local environment, an individual farmer is limited in terms of dealing with and managing prevailing influences. Rather, the formation of farmers into groups or even organisations representing the beef industry becomes effective in responding to these environmental influences.

Lastly, the global environment has a much wider scope affecting the beef industry across nations. At this level, national guidelines and treaties are influential on animal production and animal identification. National guidelines on animal identification are not as impactful as domestic legislation because they are voluntary. What is more impactful with respect to the global environment is the power of the consumers. Globally, consumers demand assurance of quality and food safety. The migration into the traceability system is nothing but a response by beef producing countries towards customer demands.

Livestock producers as well as other stakeholders in the supply chain need a strategy to manage the impact and influences of environmental factors on a continuous basis. Awareness of current trends in the global environment would assist with the formulation of such strategy. Equally, being oblivious of national and global imperatives could spell disaster for individual farmers and the beef industry.

5.2.3 The "Farm to Fork" and "Fork to Farm" Philosophy

The "Farm-to-Fork" and "Fork-to-Farm" philosophy also referred to as forward tracking and downward tracking was discussed extensively in Chapter 2. This philosophy assumes that as products are distributed from farm to consumers, details concerning animal identification, production, processing and distribution is captured and transferred from one stage of the supply chain to the next. The transfer of information from one stage of the supply chain to another is accumulative. This is because as the product moves from one stage of the supply chain to the next, information originated in each phase is incorporated into the product or batch labelling. If all stakeholders keep good records of production or processing, then traceability will be achieved and so will checks and balances be maintained to ensure food quality and safety. Further, maintenance of production information as well as the ability to transfer this information from one stage of the supply chain to the next means that products can be traced from "farm-to-fork" and *vice versa.*

The information flow process through the supply chain is made complex by the fact that there are numerous stakeholders involved and whose full cooperation is required. Figure 5-2 depicts information distribution flow from the point of origin (the farm) to the consumer. The diagram uses colour codes to distinguish between different stages. Also, colour coded multiple arrows have been incorporated to indicate the level of information that is added to original data at each stage.

It must be noted that a linear process approach has been adopted to design the diagram to demonstrate the "farm-to-fork" concept in the most simplistic manner possible. It is well understood that in real life situations, "farm-to-fork" and "fork-to-farm" are not necessarily a linear process. It is a complex process of horizontally and vertically integrated networks of information on food, food-producing animals, substances used in production, processing and distribution of food products (Chang, Tseng et al. 2013). For example, a farm has a number of suppliers and suppliers' suppliers, all of whose farm input information needs to be recorded. The abattoir, warehouse, distributors and retailers also have suppliers and supplier's suppliers whose inputs may affect or come into contact with animal products and as such, also needs to be recorded.

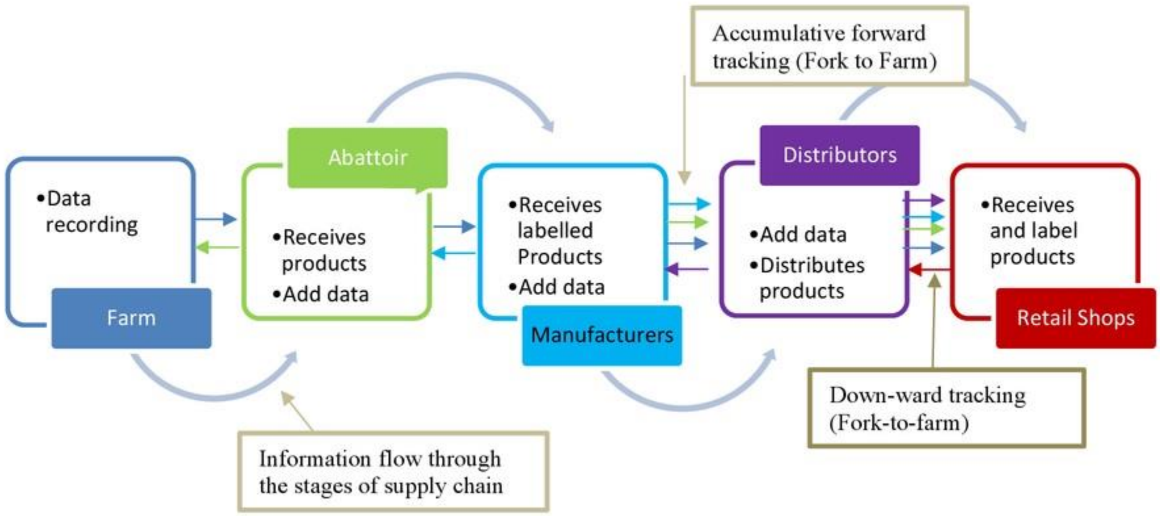

Figure 5-2: Distribution of animal products from farm to retailer

The philosophy of "farm-to-fork" and "fork-to-farm" basically implies a link between producers and consumers (Grande and Vieira 2013). This link is achieved by integrating RFID into the supply chain.

5.3 Understanding Animal Identification and Traceability in the Study Area

Animal identification in the study area follows a dual practice of inconvenient and convenient methods. The coexistence of dual methods indicates two factors. Firstly, farmers view livestock as important assets or means of production contributing to livelihoods and personal worth. As such, ownership and the proof thereof are of importance. Both inconvenient and convenient methods of animal identification are used as appropriate mechanism to ascertain ownership.

Secondly, the use of a dual practice indicates the level of confidence farmers have with respect to current methods of animal identification. The dual approach practice suggests that farmers are not able to prioritise one method over another in terms of its importance and effectiveness. The combined application of animal identification thereof enhances its effectiveness by ensuring that the possible weakness of one method is compensated by the strength of the other. If farmers had full confidence on the one method over the other, there would be no need for dual animal identification methods. At least, what would have been the case is that, some farmers would have used one method while others used the other. However, the study found that there was a high percentage of farmers who combined both animal identification methods, suggesting that each farmer used both inconvenient and convenient methods simultaneously.

The discussion about dual animal identification practices creates a good understanding of the current methods used by farmers in the study area. The other important dimension of this discussion is to determine whether any of the two methods currently used by farmers support traceability. The question whether a traceability system existed in the study area was measured using different approaches. On questions to determine acceptability of RFID, the following observations were made: 61% indicated that RFID will enhance animal recording, 54% suggested that RFID will enhance traceability, 76% agreed that RFID will ease isolation of affected animals and that 72 % concurred that RFID will enhance consumer confidence. The significance of this observation is the suggestion that currently, traceability of animals and animal products in the study are does not exist. If it existed, these responses would not have been so emphatic in suggesting an anticipated future change in this regard.

Apart from the research findings, there is yet significant evidence suggested in the literature review. The current regulations in South Africa explicitly exclude information technology methods of animal identification. Given that traceability is almost synonymous with information technology, it is safely concluded that this study did not find any evidence suggesting that there is be any form of animal traceability in the study area.

5.4 Impact of Current Animal Identification on Traceability

Now that the state of current animal identification has been determined and so are environmental factors; enablers: "farm-to fork", "fork-to farm" philosophy, it is important to consider the impact of current animal identification. The impact of current animal identification on traceability or lack thereof can best be understood in relation to the number of activities of stakeholders that are in involved in the supply chain.

Even in a small circle such as Msinga, a network of players in the supply chain can be quite complex. Being at the centre, livestock producers are at the one end of the spectrum connected to suppliers of production inputs and customers at the other end. An example refers to medicine and animal vaccines. These products are supplied to livestock producers by retailers who may have sourced these from manufacturers. The medicine and animal vaccines manufacturers buy ingredients and packaging material from their respective suppliers. In the case of this example, inputs supplied to livestock farmers are used in the cause of production. Once the production cycle is complete, livestock producers supply live animals to buyers who in turn may, in the case of an abattoir; slaughter, process, package and distribute meet products to retail shops. Already, the networking process in the livestock production value chain appears quite complex and requires efficiency in recording and keeping information. If the production system is unable to capture all information regarding the supply of input and production, traceability will either be immensely compromised or may not be achieved at processing, packaging and distribution. Discussions in Section 5.2.1.7 above clearly suggested that there is no support for animal identification and traceability system at Msinga, this has severe implications for traceability of animals and animal products. The point of origin is the primary level for data capturing about details of animals for it to be transferred to secondary levels in the supply chain such as the abattoir and so forth. The current animal identification system at Msinga and other rural areas of South Africa are not geared towards traceability. Therefore, animals sourced from these areas cannot be fully traced to the place of origin.

It is also important to indicate that lack of traceability in the study area is not entirely caused by livestock farmers, it is a broader problem. In countries where traceability is effective, it is because there is a national system of traceability which is managed by government or a designated authority. Example of such national traceability systems and authorities responsible were discussed sufficiently in Chapter 2. In fact, even before a national system, countries have put in place a regulatory framework. While legislation was sufficiently discussed in Chapter 2, it is important to further reflect on the South African situation regarding the traceability system. Apart from the work carried out by various provinces affected by FMD, the work by different beef abattoirs and plans to introduce ear tags on cattle in KZN, this study did not find any evidence suggesting that the South African government was planning to migrate to RFID.

It must be emphasised that the fact that RFID for animal identification has not been adopted, does not mean that there is not capacity for traceability systems in South Africa. Extensive work has been done to ensure that traceability is implemented in the fruit and wine industries in South Africa (Department of Agricculture Forestry and Fisheries 2007, GS1 2008). The agricultural products of plant origin have an added advantage in that there is a clear regulation supporting traceability of these products. The Agricultural Products Standards Act (Act No. 119 of 1990) regulates standards of agricultural products destined for export markets.

Chapter 2 identified a gap in legislation in that while the Meat Safety Act (Act No. 40 of 2000) seeks to promote safety standards through traceability, the Animal Identification Act (Act No. 6 of 2002) is silent in this regard. It thus suggests that food quality and safety standards are not achieved with respect to the beef industry. A relatively well resourced country like South Africa should at least be taking cue from its neighbours such as Botswana and Namibia and adopt an animal identification and traceability system. This idea is even more compelling considering the fact that South Africa was recently banned from exporting beef products due to the FMD outbreak. This ban was lifted by OIE on condition that stringent measures to deal with and control FMD outbreaks are convincingly put in place.

5.5 The role of government

Implementation of RFID requires government involvement in a number of ways. Firstly, the government has a role to play with respect to passing legislation to enhance animal identification and traceability (Bai and Li 2014). Such legislation is important to provide a legal framework and guidance on compliance, particularly to maintain food quality and safety. Secondly, the government has a role to play in respect of food quality and safety (Republic of South Africa 2002). This will ensure that food products supplied to customers will not cause food incident concerns. Lastly, the government can play a role with respect to funding the introduction of RFID, especially in the case of poor-resource-farmers (Skaggs 2011, Meat Board of Namibia 2012, Jenjezwa and Seethal 2014).

5.6 RFID as a Solution to Improve Animal Identification and Traceability

To address the question whether RFID has the potential to improve animal identification and traceability in rural areas, this section draws from the global experiences and conducts a statistical test. The global experience in this regard is based on literature review as discussed in Chapter 2, while the statistical test is based on research results presented in Chapter 4.

5.6.1 Experiences of Other Countries

In spite of its limitations and challenges, there is no doubt that RFID is useful in improving animal identification and traceability. Based on international experiences, RFID has been adopted by a number of countries to introduce better practices to manage animal diseases and outbreaks including BES and FMD. These countries include well developed economies like the US and European countries. Although there is sufficient evidence in literature suggesting that food safety has been the key driver for countries to adopt RFID, there are three other significant uses of RFID.

Firstly, countries have adopted RFID to manage the aftermath of animal disease outbreaks and to prevent its recurrence through proactive surveillance and isolation of affected animals. Chapter 2 clearly demonstrated that countries like the US and EU which have once been banned from international export were able to regain recognition after adopting RFID. To be able to regain international export status and consumer confidence on the basis of improved food safety is an indication that RFID is an effective technology to enhance traceability of animals and animal products.

The second reason why RFID has been adopted by different countries is for the purpose of accessing premium markets and expand the market share. In Chapter 2, it was demonstrated that the demand for food quality and safety is not necessarily conditional to animal disease outbreak. Consumers want to be guaranteed of the quality and safety of products, whether animal disease outbreaks have occurred or not. In addition to consumers, there are a number of organisations who are interested in knowing whether production practices have an impact on the welfare of animals as well as the environment (Schroeder and Tonsor 2012). To deal with the demand of these organisations, some countries have adopted RFID proactively. This also has a positive effect on product differentiation and consumer confidence. This is yet additional evidence that RFID is trusted to be an effective technology to enhance traceability.

Lastly, RFID is regarded as effective technology to improve production, management of inventory and bringing about efficiencies in the supply chain. The study has deliberated extensively on gains associated with product quality and safety offered to customers as this achieves product differentiation, competitive advantage and profit gains. For these reasons, this study is of the opinion that indeed RFID has a great potential to enhance traceability of products in general and animals and animal products in particular.

Based on the experiences of economies that have adopted RFID, it is clear that while this technology has some limitations with respect to functionality, there are a number of economic benefits. There are also negative consequences associated with operating outside the framework of the traceability system. The consequences are also very clear. They include poor access of premium markets, inability to differentiate products and lack of consumer confidence. Most importantly, countries that do not have traceability systems are easily banned from export markets in the event of viral disease outbreaks. This is because such countries are not able to prove beyond doubt that infection can be isolated and managed with expediency. Countries that have been banned from export markets have also lost a significant amount of trade. Even more compelling is the fact that countries may not be adopting traceability systems to save costs, but in reality, the cost of losing profit and reactive measures to control outbreaks are more likely higher.

5.6.2 Hypothesis Test

In addition to some theoretical constructs discussed in Section 5.2 above, there is still a need to conduct a statistical test. This study adopted a survey as research strategy to test the acceptability of RFID among the livestock farmers at Msinga. The purpose of the study was translated into the hypotheses presented in Chapter 1, i.e. Ho and H_1.

This Section presents the outcome of statistical test conducted to determine whether to accept or reject the null hypothesis. A Chi-Square was used to test the hypothesis. This test was based on data collected from respondents based on the assumption that: (i) farmers will not accept RFID as a solution to improve animal identification and traceability; and (ii) farmers will accept RFID as a solution to improve animal identification and traceability. Data to these questions was collected randomly from 170 respondents.

The Chi-Square was calculated following six sequential steps outlined below. Further, in addition to the Chi-Square formula, the process relied on degrees of freedom formula and determination of a Chi-Square Table value, which is based on both the degree of freedom and the level of significance (LOS) desired. The process of calculating the Chi-Square culminated in two important outcomes: the calculated Chi-Square value and the Chi-Square table value. These values were then plotted in a distribution curve known as "critical region" which is divided into two areas, the area of acceptance and the area of rejection. The decision to accept or reject the null-hypothesis was informed by the calculated Chi-Square value and the Chi-Square table value. The actual calculation of the Chi-Square followed six sequential steps as outlined below:

Step 1: State the hypothesis

H_o (null hypothesis): Famers will not accept RFID as solution to improve animal identification and a traceability system.

H_1 (alternative hypothesis): Famers will accept RFID as solution to improve animal identification and a traceability system.

Step 2: State Level of significance

The desired LOS, (denoted as α) for this test is = 0.05. This is the most commonly used LOS.

Step 3: Test Statistic

A statistical test was conducted based on the Chi-Square formula below:

$\chi^2_{calc} = \sum \frac{(fo - fe\ )2}{fe}$

Let: fo = observed frequency = frequencies of farmers not willing to accept RFID

fe = expected frequency = frequencies of farmers willing to accept RFID

It must be noted that the observations of farmers not will to accept (fo) and those willing to accept (fe) used in the calculation of the Chi Square are based on the findings presented in Section 4.1.5 dealing with the question of acceptability of RFID.

Where Degrees of freedom = $\sum \frac{\text{row marginal} - \text{colum marginal}}{\text{Expected}} = \frac{5-1}{1} = 4$

And: $\chi^2_{calc,}$ Denotes the calculated value of Chi Square

Therefore, using the observations presented in Figure 5-3 above, the χ^2_{calc} equals:

Table 5-2: Calculation of Chi-Square

	f_o	f_e	$f_o - f_e$	$(f_o - f_e)^2$	$\frac{(fo\ - fe\ )^2}{fe}$
Strongly disagree	17	8	9	81	10
Disagree	37	7	30	900	129
Neither agree nor disagree	59	35	24	576	16
Agree	36	72	-36	1296	18
Strongly agree	21	48	-27	729	15
Σ	170	170	0	Σ (or χ^2_{calc})	188

Step 4, Critical Region: Figure 5-4 below demonstrated two critical regions, area of acceptance, and rejection area.

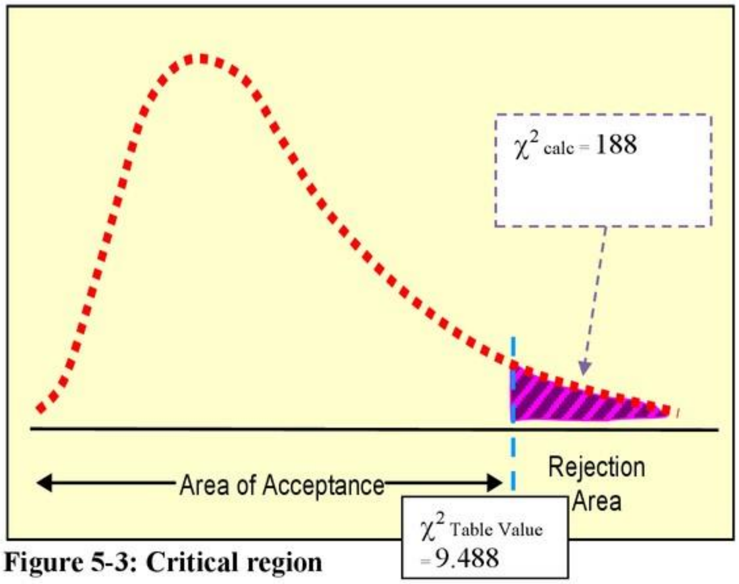

Figure 5-3: Critical region

Step 5: Decision Rule:

If the calculated Chi-square value is equal or greater than the Chi-Square table value, then **reject** the null hypothesis.

Step 6, Conclusion:

Since χ^2_{calc} (188) > α (0.05), = 188 > 9.488, the study fails to accept Ho (null hypothesis). There is sufficient evidence suggesting that at 95% or 0.05 LOS farmers will accept RFID as a solution to enhance animal identification and traceability.

5.7 Conclusion

The discussion of research findings in this Chapter was presented in three main sections. The first section focused on developing some theoretical constructs around animal identification and traceability. This was supported by the development of a toolkit serving as a checklist of all dimensions of radiofrequency identification that needs to be in place to give rise to effective traceability. This section also identified some environmental factors affecting animal identification in general and animal production in particular. Part of the theoretical constructs was to present an analysis of distribution of animals and animal products to consumers through the philosophy of "farm-to-fork" and "fork-to-farm". The presentation of theoretical constructs was largely based on the literature review.

The second part focused on analysis of the current status of animal identification within the study area. An effort was made to make sense of the impact of current animal identification to animal traceability. This was based largely on the research findings. The last part was concerned with the testing of the hypothesis using a Chi-Square test.

All three main sections of this Chapter sought to address two questions: firstly, whether current animal identification in the study area supports traceability and secondly, whether RFID could enhance traceability. The use of the toolkit developed as part of the theoretical construct, clearly indicated that the current form of animal identification in the study area does not support traceability. Also, this analysis indicated that even the legislation in the case of South Africa does not support traceability. Given that there was no evidence of animal traceability in livestock production, a traceability system starting at the abattoir stage of the value chain is almost of no use. Lastly the Chi-Square test indicated strong evidence that farmers in the study area will accept RFID as solution for animal identification and traceability.

Chapter 6 Conclusions and Recommendations

6.1 Introduction

This final Chapter presents overall conclusions of the study and make recommendations on the use of RFID in a rural setting and its impact thereafter. Given that the study was partly triggered by the plan of the KZN Department of Agriculture and Rural Development to introduce RFID, recommendations presented in this Chapter reflect on whether this plan is worth pursuing.

6.2 Conclusion

A quantitative approach was adopted by this study to collect data from 170 respondents at Msinga, a rural area in central KZN. Quantitative instruments to collect and analyse data were cautiously selected with a view to minimise errors and biasness and to enhance the quality of the study results. These instruments included the probability approach, random sampling, sample frame, objective calculation of sample size, structured questionnaires and the use of trained field workers to administer the questionnaires. During data capturing, trends of consistency in responses on similar questions asked differently were observed. Such level of consistency on findings was also on par with the existing empirical evidence discussed in Chapter 2. Coupled with the degree of correlation of responses obtained through the use of different instruments, consistency between research findings and empirical evidence indicated gains of carefully selecting research methods to minimise the margin of error.

Central to this study was to determine the value of applying advanced technology to deal with and solve rural problems. Key to this is acceptance of advanced technology by rural dwellers, in particular to improve animal identification and traceability. In addressing this question, it became important to understand animal identification practices as well as potential impact of RFID.

Literature review demonstrated that a number of first world economies have adopted RFID to enhance traceability systems. The primary purpose has been to guarantee food quality and safety to consumers. This was prompted largely by food safety incidents in US, Europe and other countries. RFID is triggered by a number of reasons, principal to them being customer demand for food safety through traceability. Other triggers include the need to improve supply chain efficiencies, management and monitoring of inventories, building competitive advantage, gaining access to lucrative international markets and profit gains.

The study found that animal identification at Msinga still relies on unauthorised methods of marking animals which are used alongside authorised methods. Nevertheless, none of these methods are supported by sophisticated information technology. As such, animal identification records are not well kept. As a result, there is no proper transfer of animal records from farmers to buyers. This has severe implications for maintaining traceability through the supply chain as traceability relies on good records on production at the farm level. The observations of the study findings indicate that current animal identification methods in the study area do not have the capacity to maintain traceability. It has also been demonstrated that new methods based on RFID would be accepted and are seen as having the potential to enhance animal records and traceability. This study has deliberated extensively on the risk of operating outside a traceability framework when the world economy is migrating to traceability system. Penalties are clear and severe, market access and growing the beef economy becomes difficult.

The study developed theoretical constructs, animal identification and a traceability checklist and "farm-to-fork" philosophy. These were based on literature review and on the findings of the study, and intend providing an analytical understanding of the intricacies of RFID. The theoretical constructs also serve as yardstick to measure whether traceability exists, and also whether an environment is favourable for it to be implemented. Applying the developed theoretical constructs and a toolkit for RFID enablers, it became apparent that globally, the environment for implementation of RFID in South Africa is favourable. They include availability of international guidelines; RFID technology market pull factors are in place for any potential user to adopt this technology with ease. The South African situation including animal disease outbreak and the need to tap into premium markets clearly indicates that there is a need for the adoption of RFID. However, the major hindrance is the absence of appropriate legislation. Affordability might be a hindrance but this is not a major factor as solutions can be worked out.

Due to carefully selected instruments for defining the population, selecting the sample and collecting data, which minimised errors and biasness, as well as ensured consistency in responses, the sample was representative. As a result, it is concluded that the observations made on the basis of 170 respondents is generalizable to the entire population of 1 000 livestock farmers. This means that in the study, in the abaThembu and amaMchunu Traditional Councils, animal identification is not supported by traceability systems.

In conclusion, it is important to reflect on the study objectives, namely:

i. To understand the current animal identification and traceability systems among communal farmers at Msinga;
ii. To investigate the effectiveness of the current animal identification on traceability of meat products; and
iii. To test whether farmers will accept RFID as a solution to improve animal identification and traceability system.

Based on empirical evidence and data analysis of this study, the following three conclusions are made. Firstly, in the study area and in other rural areas with similar characteristics, livestock farmers rely on manual application of brand marks as form of animal identification. This form of animal identification is supported by and regulated by the Anima Identification Act (Act No. 6 of 2002). This form of anima identification has noticeable weakness. The current animal identification could be tempered with, and as a result, livestock farmers compliment this practice with unauthorised self-designed brandmarks. Also, another major weakness of this form of animal identification, is that it does not support traceability and as such does not have the ability to effectively keep good records of animals and animal products.

Secondly, due to the fact that the current animal identification system in the study area is not capable of supporting good record keeping, this system is not effective with regards to gaining access to lucrative international meat markets. This is because one of the conditions for gaining access to these markets is a requirement to build consumer confidence regarding food safety and the quality of food. South Africa has previously been banned from export markets in the event of the outbreak of viral diseases such as the FMD. This is because in the absence of credible traceability systems, there is no effective way of disease surveillance, isolating the problem and convincing international markets that the problem is under control.

Lastly, the study sought to understand whether the livestock farmers at Msinga would accept the RFID. The answer to this question is with a high degree of confidence emphatic "Yes". An analysis of the data collected shows that the majority of farmers believe that RFID will enhance proof of ownership and develop traceability systems, improve animal breeding and selection as well as support the effective upkeep of animal records. Further, the economic gains of traceability systems have been discussed extensively in this study. The study was not able to establish in details, whether the livestock farmers would accept RFID because of gaining access to international markets. However, the study shows that countries that have adopted RFID benefit from accessing premium meat markets because of they are able to sustain consumer confidence and are able to manage problems associated with the outbreak of viral diseases. The fact that the livestock farmers at Msinga and other rural areas with similar characteristics is an advantage to South Africa. Should RFID be adopted in the country, the challenge often associated with poor uptake of new technologies does not exist in this case. This is one of the values of this study.

6.3 Recommendations

Given the absence of traceability system in the study area versus the increasing consumer awareness and the demand for food quality and safety, the advancement of information technology and the global migration to RFID, the following recommendations are made:

6.3.1 Adoption of RFID

The study emphatically recommends that South Africa consider adopting RFID. The implementation of RFID can best be implemented as a national programme. The strength of RFID in countries that had adopted this technology has been that it has been implemented as a national initiative. The danger of implementing RFID randomly in the country is that gains made could negatively be affected by what happens in other parts of the country that are without a traceability system. The effort in the Karoo, Western Cape Province, where traceability system is in place in sheep production is refuted by the that this is not a national programme. The study of the Karoo sheep production in the Western Cape, shows that, in as much as farmers have developed their own traceability mechanism, its effect is very minimal because there is no system at a national level to support this initiative. Adoption of RFID proactively is most cost effective than continuous reaction to animal disease outbreaks and trying to mend industry image.

6.3.2 Legislation

It is clear that the Animal Identification Act (Act No. 6 of 2002) was not crafted with a traceability system or other forms of information technology in mind. In light of advancing information technology and an increasing need to participate in global trade, the Act needs to be amended to remain relevant for the foreseeable future. It is only reasonable that South Africa consider amending the Act to incorporate traceability systems. In particular reference to the adoption of the RFID, the Act would be required to regulate the adoption and implementation of traceability systems and regulate the activities of different stakeholders.

6.3.3 Establishment of a Designated Authority

A designated authority to become a custodian of the national animal identification and traceability system is necessary. This body would be responsible for implementing the promulgated Act for animal identification and traceability. Among others, an established authority would be responsible for planning, designing and actual implementation, of the RFID and mobilising funds for this function. Further, an established authority would also deal with compliance issues and regulation of activities of various stakeholders in the supply chain in relation to RFID. The body would also be responsible for securing data.

6.3.4 Financial support

Recommendation is made that government contribute directly towards the cost of implementing RFID and indirectly by incentivising farmers into complying with this technology. The reason for this is that it is difficult to pinpoint a single stakeholder to bear all costs because naturally, benefits spread across the supply chain. By virtue of being able to collect tax, government can use a proportion of these levies to invest backward in the cost of implementing the RFID. It is also clear that the resource poor farmers may without doubt not afford the implementation costs. The fact is that in the event of animal disease outbreak, the economy suffers and government spends insurmountable amounts of money to correct the problem, this clearly justifies the financial supportive role of government in this regard.

6.3.5 Designing RFID Traceability System

Lastly, it is recommended that adoption of RFID takes place following a thorough process of planning and design implementation thereof. The RFID has three key elements. The design process must ensure that all elements of RFID, the infrastructure, ear tags and software have been considered. Introduction of RFID must be accompanied by a data depository and having a designated authority to be the custodian of data. Introduction of RFID that is not supported by all three elements (a tag, a reader and a server) would be futile.

6.4 Limitations of the study

Based on the analysis of the findings of the study, some limitations of the study are observed. They include the following:

i. Given that this research is quantitative in nature, there is no opportunity for obtaining the motives for farmers to be willing to accept the RFID. Also the study is not able to test whether the livestock farmers at uMsinga would have the ability to implement, operate and maintain RFID since this is high technological information system;
ii. The study was motivated by the idea that the KZN Department of Agriculture and Rural Development had a plan to introduce RFID among rural livestock farmers. In as much as the study provided a broad operational framework, it was not the scope of this study to develop a model for the implementation of RFID in a rural setting where there is no infrastructure for technology
iii. The study was not able to provide cost benefit analysis adoption of RFID by livestock farmers. This is an important limitation given that the population selected for this study

falls under low-income bracket and is relatively poor. there are no details with respect to aim of the study was to establish whether or not the livestock farmers will

6.5 Recommended Topics

The limitations of this study provide an opportunity for future research. The following topics are therefore suggested:

iv. Investigation of capabilities and enablers required by rural livestock farmers to to implement, operate and maintain RFID in sustainable manner;

v. Action research could be adopted to develop a model for the implementation of RFID in a rural setting where there is no infrastructure for technology; and

vi. Cost-benefit analysis of RFID by livestock farmers.

6.6 Conclusion

It is concluded that, the current animal identification in the area of uMsinga is not capable of keeping good records for the purposes of production management. The existing legislation on animal identification in South Africa is outdated compared to the industry demand. Countries both in well developed countries and emerging markets have adopted RFID to respond to both the market demands as well as to take advantage of advancement of technology. Although there may be question regarding affordability and ability to implement RFID, the study concludes that the rural farmers of uMsinga are ready to accept RFID.

APPENDIX B: INFORMED CONSENT

APPENDIX C: RESEARCH QUESTIONNAIRE

ACCEPTABILITY OF RADIOFREQUENCY ANIMAL IDENTIFICATION IN KWAZULU-NATAL

1. Personal information

1.1 Gender

Male	Female
1	2

1.2 Respondent's age

Below 20 years of age	Between 21 and 30 Yrs of age	Between 31 and 40 Yrs of age	Between 41 and 50 Yrs of age	Between 51 and 60 Yrs of age	Above 61 Yrs of age
1	2	3	4	5	6

1.3 Marital status of the respondent

Married	Single	Divorced	Widow	Widower
1	2	3	4	5

1.4 Number of dependants to the respondent

None	Between 1 and 4	Between 5 and 8	Above 9
1	2	3	4

1.5 Respondents' Level of education

	LEVEL
1	No formal education
2	The level of education is below Grade 7
3	Above Grade 7 but below Grade 12
4	Has Grade 12 but not Tertiary qualification
5	Has a Diploma
6	Has a University Degree

1.6 Respondents' level of income

	LEVEL OF MONTHLY INCOME
1	Below R1 000.00
2	Between R1001.00 and R3 500.00
3	Between R3 500.00 and R5 500.00
4	Between R5 501.00 and R7 500.00
5	Between R7 501.00 and R9 500.00
6	Between R9 501.00 and R11 500.00
7	Between R11 501.00 and R13 500.00
8	Above R13 501.00

1.7 Number of livestock owned by the respondent

		Cattle	Goats	Sheep	Horses	Donkeys	Pigs
1	Less than 10						
2	Between 11 and 20						
3	Between 21 and 21						
4	Between 31 and 40						
5	Between 41 and 50						
6	Between 51 and 60						
7	Between 61 and 70						
8	Above 71						

1.8 How long has the respondent kept livestock

	Period
1	Less than 1 year
2	More than one year but below 10 years
3	More than 10 years but below 20 years
4	More than 20 years but below 30 years
5	More than 30 years

2. What methods do farmers use in the area as form of animal identification to certain their ownership

2.1 Most livestock owners name their livestock as form of animal identification

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

2.2 Most livestock owners use the colour of the animals as form of animal identification

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

2.3 Most livestock farmers brand animals using random symbols they have created themselves

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

2.4 Livestock owners register for Animal Identification Certificate with the Department of Agriculture and Fisheries

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

2.5 Livestock owners brand their animals using brand marks provided in accordance with the Animal Identification Certificate

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

2.6 Livestock owners use a combination of self-created brand marks and brand marks provided for in accordance with the Animal Identification Certificate

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

3 Acceptance of Radio Frequency Animal Identification

3.1 Livestock owners gladly accept RFID because each and every animal would have unique identity

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

3.2 Livestock owners are reluctant to accept RFID on the basis that it will be expensive

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

3.3 RFID will increase confidence for livestock ownership thus deter stock theft

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

3.4 RFID will improve record keeping required for breeding and selection

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

3.5 RFID will provide production management information and increase consumer confidence

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

3.6 RFID will facilitate isolation sick animals for diseases management

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

4 Effectiveness of traditional animal branding as a management tool in respect to record keeping for breeding and selection

4.1 I believe that animal branding assist livestock owners to keep proper records in respect of breeding and selection

Not at all	Very little	Somewhat	To a moderate extent	To a large extend
1	2	3	4	5

4.2 Animal branding does not assist livestock owners to keep proper records in respect of breeding and selection

Not at all	Very little	Somewhat	To a moderate extent	To a large extend
1	2	3	4	5

4.3 Due to the fact that animal branding does not provide unique identification, it becomes difficult to isolate sick animals for disease management purposes

Not at all	Very little	Somewhat	To a moderate extent	To a large extend
1	2	3	4	5

4.4 During animal branding all records relating to the history of the animal is properly recorded manually

Not at all	Very little	Somewhat	To a moderate extent	To a large extend
1	2	3	4	5

4.5 Customers never ask for information on animal production and management regime

Not at all	Very little	Somewhat	To a moderate extent	To a large extend
1	2	3	4	5

4.6 During the sale of live animals, livestock owners, pass on records of the animals to the buyers

Not at all	Very little	Somewhat	To a moderate extent	To a large extend
1	2	3	4	5

APPENDIX D: TURNITIN REPORT

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