THE FINANCIAL IMPACT OF SHEEP THEFT IN THE FREE STATE PROVINCE OF SOUTH AFRICA

BY WILLEM ABRAHAM LOMBARD

Submitted in accordance with the requirements for the degree

MAGISTER SCIENTIAE AGRICULTURAE

in the

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JANUARY 2015

FACULTY OF NATURAL AND AGRICULTURAL SCIENCES

DEPARTMENT OF AGRICULTURAL ECONOMICS

UNIVERSITY OF THE FREE STATE

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DECLARATION

I, Willem Abraham Lombard, hereby declare that this dissertation submitted for the degree of *Magister Scientiae Agriculturae* in the Faculty of Natural and Agricultural Sciences, Department of Agricultural Economics at the University of the Free State, is my own independent work, and has not previously been submitted by me to any other university. I furthermore cede copyright of the thesis in favour of the University of the Free State.

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ACKNOWLEDGEMENTS

First of all I want to thank our Lord Jesus Christ, who gave me the ability, wisdom and opportunity to complete this study.

I specifically want to thank my wife, Marese, as well as my whole family for their continued support, motivation and patience.

I would also like to express my sincere gratitude towards the following people, organisations and institutions that made this study possible:

- Mr Walter Van Niekerk, supervisor and colleague for his continuous supervision, guidance, support and encouragement throughout the study.
- Dr Antonie Geyer, my co-supervisor and colleague for his supervision, support and guidance.
- Dr. Henry Jordaan for his guidance and support whenever it was required.
- Mr Willie Clack for sharing his knowledge on the topic and his guidance.
- Mr Albert Loubser and Mrs Lynette Louw, editors of Plaas Publishing, for initiating and supporting this study in the field of livestock theft. Without their support this study would not have been possible.
- Mr Günther Griessel, Mr. Frikkie Maré, Dr. Nicky Matthews, Prof. Johan Willemse, Mr Herman Lombard, Dr. Abioden Ogundeji and Dr Yonas Bahta who all gave advice and guidance in their own capacity.
- Mrs Louise Hoffman, Mrs Chrizna Van der Merwe and Mrs Ina Combrinck secretaries at the Department of Agricultural Economics, for assisting me with much more than just administrative duties.
- My other colleagues at the Department of Agricultural Economics, University of the Free State, for their continued support.
- The farmers who were willing to complete the questionnaires, without them this study would not have been possible.
- The Red Meat Producers Organisation (RPO) of the Free State who was willing to supply the contact details of their members and helped to prepare the farmers.
- Veeplaas magazine for their support throughout the study.
- The Red Meat Research and Development Trust (RMRDT) who provided the funding for collection of the data.
- The National Research Foundation (NRF) for their financial assistance.

The views expressed in this dissertation do not necessarily reflect those of the RPO, Veeplaas, RMRDT or that of the NRF.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADL	Autoregressive Distributed Lag
DAFF	Department of Agriculture, Forestry and Fisheries
ha	hectare
NSTPF	National Stock Theft Prevention Forum
R	South African Rand
RPO	Red Meat Producers Organization
SA	South Africa
SAPS	South African Police Service
VIF	Variance Inflation Factor

The financial impact of sheep theft in the Free State Province of South Africa

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Abstract

In South Africa, livestock theft is nothing new to farmers and is considered by some to be as old as farming itself. Recorded cases of livestock theft in South Africa can be traced as far back as 1806. Livestock theft affects the livestock industries in all nine provinces of South Africa, with stock theft being a priority crime in most of the provinces. Livestock theft is not a unique problem that is confined to South Africa or even Africa.

Available studies on livestock theft have only focused on the direct cost of losses. However, no study has been done to quantify the direct, as well as indirect cost of livestock theft in the Free State Province of South Africa. Indirect cost represents the cost of loss-controlling practices performed by farmers against livestock theft.

The primary objective of this report is to quantify the financial impact or implications of sheep theft in the Free State Province of South Africa. Secondary objectives include the distinguishing of direct and indirect costs of livestock theft. It was also deemed important to identify variables affecting sheep livestock theft in the Free State Province. Investigation of the variables will help to better understand the occurrence of livestock theft in the Free State Province.

This survey was conducted in the Free State Province of South Africa and included respondents from all five of the district municipalities. The sample used consisted of 292 respondents representing 159 081 sheep or 3.31% of the sheep in the Free State Province. A structured questionnaire was used to collect the data during telephonic interviews with livestock farmers. The questionnaire included questions on topographic factors, demographic factors, and the control practices that farmers are using to protect their livestock.

All five of the district municipalities are affected by livestock theft with the highest annual loss rate occurring in the Lejweleputswa district (5.98%) and the lowest annual loss rate occurring in the Xhariep district (0.96%). It was found that 84 955 sheep are annually lost to stock theft in the Free State Province. To put this in perspective, this number is more than four times the number shown in official statistics. The total annual direct cost of livestock theft in the Free State Province is estimated at R144 423 500. The total annual indirect cost of livestock theft (control practices) was determined at R38 536 894. Therefore, the total annual cost of livestock theft in the Free State Province is estimated at R182 960 394.

The data were used to investigate the variables affecting livestock theft. A Tobit (level), Probit (occurrence) and Truncated (level) model was used to identify variables associated with the occurrence and level of livestock theft experienced. The Craggs test was used to determine whether the variables affecting the occurrence of livestock theft are significantly different from the variable affecting the level of livestock theft experienced. The Granger Causality test was used to determine the direction of causality for variables that had a significant relationship with livestock theft.

The results suggest that the longer farmers take to report stock theft cases, the more likely they are to experience stock theft. It was also determined that some farmers are taking longer to report cases due to the high level of stock theft they experience. In some cases where sheep are corralled at night in an attempt to control the occurrence of livestock theft, it has also led to higher occurrence rates of stock theft. Farmers near the Lesotho border experience stock theft on a more regular basis than the rest of the Free State Province, though not at higher levels.

The information that was collected during the study confirms that livestock theft has a major impact on the livestock industry in the Free State Province. Also, official stock theft statistics do not accurately represent the actual losses experienced by farmers. This study does not provide all the answers to the problem; however, valuable information regarding the direct and indirect cost was determined as well as some variables affecting livestock theft. If similar research could be done in other parts of the country, the findings could serve as guidelines to livestock owners across South Africa to control livestock theft.

Keywords: Livestock theft, direct cost, indirect cost, total cost, internal variables, external variables.

CHAPTER 1

INTRODUCTION

1.1 Background

Livestock theft is nothing new to South African farmers and is considered by some to be as old as farming itself (PMG, 2010; Clack, 2013). Recorded cases of livestock theft in South Africa can be traced back to 1806 (Alberti, 1811 cited by Peires, 1994). In some African cultures cattle raiding (livestock theft) formed a major part of warfare. It was even considered legitimate to enter neighbouring chiefdoms and raid their cattle during times of peace. These raiders who returned with large numbers of cattle were seen as heroes, while petty thieves were despised (Peires, 1994). Livestock theft is not a unique problem that is confined to South Africa or even Africa. Various countries also experience livestock theft and have done research to try and identify causes and solutions to this problem. African countries include Lesotho (Khoabane & Black, 2012), Kenya (Anderson, 1986; Cheserek, Omondi & Odenyo, 2012; Bunei, Rono & Chessa, 2013) Eritrea (Mohammed & Ortmann, 2005) and Nigeria (Olowa, 2010), while other countries include America (Anderson & McCall, 2005) and Australia (Barclay & Donnermeyer, 2001). From reviewed literature it seems that livestock theft has become more violent and organized in recent years where guns are used in perpetrating these thefts. One of the main causes of livestock theft is poverty among unemployed and drought-stricken crop farmers (Dzimba & Matooane, 2005; Cheserek, *et al*., 2012; Khoabane & Black, 2012). When comparing stock theft to other crimes in the country it may seem as a minority crime and because of this minority view research on the topic has been neglected (Clack, 2013).

Although there are many definitions for stock theft, the best definition can be defined as according to regulation four of the South African Stock Theft Act 57 of 1959, (Department of Justice, South Africa 1959: 2). The act defines stock theft as "*Any person who in any manner enters any land enclosed on all sides with a sufficient fence or any kraal, shed, stable or other walled place with intent to steal any stock or produce on such land or in such kraal, shed, stable or other walled place, shall be guilty of an offence*."

All provinces in South Africa are affected by stock theft and it is a priority crime in most of the provinces (PMG, 2010). Crime statistics show that the occurrence of stock theft has increased in the past few years and the number of sheep, cattle and goats stolen annually increased from approximately 160 000 animals in 2004/05 to over 200 000 in 2011/12 (up by 25%), followed by a decrease to approximately 172 000 animals in 2013/14 (down by 16%) (Clack, 2013; NSTPF, 2014). Livestock theft affects both the commercial and emerging farm sectors (PMG, 2010). The Red meat Producers Organization (RPO) stated that the emerging sector is hit the harder of the two sectors (RPO, 2012a). Cross-border stock theft intensified during the 1990's. It has become more widespread, organised and violent (PMG, 2010). One can assume that livestock theft has become a lucrative action attracting crime syndicates (Clack, 2013). Instead of stealing three or four sheep, farmers now have to deal with syndicates who steal truckloads full at a time (PMG, 2010). Livestock theft has caused tension and suspicion that might lead to low-level civil wars and even death in some cases (PMG, 2010).

Stock theft alone caused losses up to R300 million within the South African red meat sector (sheep, cattle and goats) during 2012. The value of losses showed a substantial increase to approximately R514 million in 2013/14 (RPO, 2012a; RPO, 2014). When comparing losses for 2013/14 with the annual gross income from the red meat sector for 2013/14, it can be seen that the gross income could have been increased by approximately 2.3% if stock theft could have been prevented (DAFF, 2013a). Of greater concern is the fact that the official stock theft numbers and value of losses are underestimated (Scholtz & Bester, 2010; Clack, 2013). National livestock theft statistics coincide with the abovementioned trend, the number of livestock theft cases reported has declined by approximately 26% since 2003/04 until 2011/12, while the number of animals stolen annually has increased roughly 20% from 2004/05 until 2011/12 (South African Police Service, 2009; Clack, 2013; South African Police Service, 2014).Thus, larger numbers of animals are stolen per theft incidence. One explanation could be the fact that not all victims of stock theft are reporting their cases with the non-reporting rate standing at 64.4% for the period 2013/14 (Statistics South Africa, 2014a) Livestock theft statistics show that all nine provinces are victims of stock theft, but some provinces are affected more adversely than others. In 2013/14 the second largest number of sheep was stolen in the Free State Province, namely 22 014 (NSTPF, 2014).

Farmers not only have to deal with controlling livestock theft (Clack, 2013) but also other problems such as predators (Van Niekerk, 2010; Badenhorst, 2014) and extreme weather conditions (draught, animal diseases, etc.) (BFAP, 2014). As the cost of controlling these problems increase, more pressure is placed on the farmer's profit margin. In some cases livestock farmers have already left the livestock industry because of stock theft, resulting in a shortage of supply and increased prices threatening sustainability (PMG, 2010).

1.2 Motivation

South Africa has a magnitude of 1 219 090 km^2 and 80% of this land is primarily suitable for extensive livestock farming (mainly sheep and cattle farming) (DAFF, 2012; SA. Info, 2013). Since 1970 the primary agricultural sector has grown on average at 11.8% annually (DAFF, 2013b). Gross farming income for the year 2013 was R178 050 million. Animal products[1] contributed R83 637 million. Animal products thus generated 46, 97% of the gross farming income (DAFF, 2013b).

[1] Animal product consist of: slaughtered sheep, cattle, calves as well as poultry meat, egg production, milk production, wool and ostrich products.

Furthermore, agriculture contributed 2.2% of South Africa's Gross Domestic Product (GDP) for 2013 (Statistics South Africa, 2014b). Although it may seem like agriculture plays a small role in the country's GDP, it provides employment for many people, especially in rural areas. Approximately 70% of agricultural outputs are used as intermediate products in the sector and is therefore, one of the important sources of growth for the rest of the economy and is responsible for a significant inflow of foreign exchange (DAFF, 2013b). In 2001, 960 000 people of South Africa's population of 44 561 million worked in the agricultural, hunting, forestry and fishery sectors (DAFF, 2013a).

The number of sheep, cattle and goats stolen has shown an increasing trend over the last few years. Official statistics show that 79 713 sheep, 56 954 cattle and 34 988 goats were stolen during 2013/14 (NSTPF, 2014). In the case of stolen sheep, approximately 21% of the sheep were recovered. For cattle the success rate seems better with approximately 39% of stolen cattle being recovered. Just more than 30% of the stolen goats were recovered (NSTPF, 2014). These losses are taking place while the total amount of sheep meat and beef consumed in South Africa increases annually. Predictions indicate that the total consumption of sheep meat and beef will increase with 15% and 20% respectively up to 2023 (BFAP, 2014). With this increase in consumption South Africa remains a net importer of these meats (BFAP, 2014). Thus, stock theft is one of the biggest problems that the South African red meat producers are facing and threatens South Africa's food security (RPO, 2012b).

1.3 Problem statement

Livestock theft is no new problem for livestock farmers; however, when reviewing available literature and statistics it can be seen that livestock theft numbers have shown an increasing trend during the past few years. In some cases it seems that livestock thieves make use of firearms and that livestock theft has been commercialised, with crime syndicates stealing larger numbers of animals at a time. This trend could be one of the contributing factors to the fact that more farmers are leaving the livestock industry, placing more pressure on South Africa's food security.

The annual economic impact of livestock theft in South Africa was reported at a value of R514 million (RPO, 2014). Worse still, is that official statistics are shown to be underestimated. While available literature has investigated the number of animals lost (direct costs), no scientific investigation has focused on which loss-controlling practices farmers are using and the cost of these practices (indirect cost). To get the true financial impact of livestock theft, both the direct and indirect costs are required. The internal and external variables affecting the occurrence of livestock theft under South African conditions have not been investigated as yet. If the variables are identified and investigated it can increase understanding of the current problem and could be used to control livestock theft.

1.4 Objectives

The primary objective of this study is to determine the financial impact or implications of sheep theft in the Free State Province of South Africa.

In order to achieve the primary objective, the following secondary objectives must be reached:

- **To quantify the direct cost of sheep theft in order to calculate the economic impact of livestock theft in the Free State Province.**

  To calculate the total cost of stock theft it will be necessary to determine both direct and indirect cost. Direct cost was calculated based on the physical losses experienced by Free State Province farmers. The number of sheep lost as calculated in the study is also compared to the official livestock theft statistics.

- **To quantify the indirect cost of sheep theft in order to calculate the economic impact of livestock theft in the Free State Province.**

  Available studies on livestock theft have only explored the cost of animals lost (direct cost) while ignoring the cost of loss-controlling practices (indirect cost) performed by farmers. The indirect cost structure is different from that of the direct cost. The indirect cost was calculated by adding all of the expenses made towards controlling sheep livestock theft by Free State Province farmers, while ignoring the cost of replacement animals. Theft control methods and actions were identified from the data in order to create an idea of what farmers are really doing to control livestock theft in the Free State Province.

- **Identify variables affecting sheep livestock theft in the Free State Province.**

  The variables are explored in order to try and better understand the trends in livestock theft in the Free State Province, as well as the effect that the loss control practices have on the occurrence and level of livestock theft. The variables explored consist of internal and external variables.

  Variables with a significant relationship to the occurrence and level of livestock theft experienced were identified by Tobit, Probit and Truncations regression. The Craggs test was used to determine whether the variables affecting the occurrence of livestock theft and the variables affecting the level of livestock theft are significantly different form each other. Once variables with a significant relationship to livestock theft were identified in the

Craggs model, a pairwise Granger Causality test was done to verify that one variable leads to the occurrence of livestock theft or *vice versa*. Once a variable proves to be significant in both the Craggs test as well as in the Granger Causality test, it can be verified that the variable has a positive or negative significant relationship with livestock theft.

1.5 Outline of the study

Chapter 2 is a literature review of livestock theft studies from around the world, local theft statistics and methods used to control livestock theft. Variables found to be affecting livestock in other studies are also identified in this chapter. *Chapter 3* explains the procedures that were followed in the study. The process used for quantification is explained as well as the Craggs Model and Grange Causality test that is used to identify variables with a significant relationship to the occurrence and level of livestock theft experienced by farmers. *Chapter 4* is a discussion of the results that will focus on the direct, indirect and total financial cost of livestock theft in the Free State Province. Furthermore, the number of sheep stolen in the study is compared to official numbers, loss- preventing practices performed by farmers identified in the data are shown and lastly the variables affecting livestock theft in the Free State Province are explored. In *Chapter 5*, conclusions and recommendations are made based on the findings of the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Reviewed literature in this chapter provides a broad review of relevant studies done on livestock theft around the world. Crime prevention is discussed from a criminological perspective followed by methods used for calculating losses and related studies from South Africa. In conclusion livestock theft control methods are discussed. The purpose of the literature review is to collect research results regarding the topic of livestock theft and stock theft control methods in order to identify gaps that still exist in scientific research.

2.2 Crime and crime prevention from a criminological perspective

Livestock theft is a crime, thus it is important to look into it from a criminological perspective. Criminology strives to understand and explain crime and criminal behaviour (Brantingham & Brantingham, 1993). First of all, crime is defined by Tappan (1947), cited by Walsh & Hemmens (2008), as "*an intentional act in violation of the criminal law committed without defence or excuse, and penalized by the state*". Various theories have been developed by criminologists to explain why crime occurs. The group of theories most applicable to livestock theft and this study is environmental criminology theories. More specifically, situational crime prevention theories will be applicable to the settings (actions taken and methods used) to make a crime less attractive (stock theft) (Anderson & McCall, 2005; Clarke, 1997; Felson & Clarke, 1998).

Environmental criminology theories investigate criminal occurrence and analyses the interaction between crime opportunities and the criminals' way of thought. Three theories fall under environmental criminology and are complementary to each other, namely (Clarke, 2013):

- Routine Activity Theory
- Crime Pattern Theory
- Rational Choice Theory

2.2.1 The Routine Activities Theory

It suggests that there are three elements needed for a crime to take place (Cohen & Felson, 1979; Benesh, 2003):

- A motivated offender
- The absence of a capable guardian

- A suitable target

Guardians in this theory can refer to a person (friends, family, etc.) or physical measures put in place (locks, alarms and cameras) to guard the property (Clarke & Felson, 1993 cited by Bunei & Chessa, 2013). If control within the theory were to decrease crime rates will increase (Cohen & Felson, 1979). Felson & Clarke (1998) state that there are four factors that influence the target's risk of attack:

- Value
- Inertia
- Visibility
- Access

Items of higher value that are easily moved, for example vehicles, have a higher risk of being stolen. This theory can be used as a crime prevention methodology, which focuses on the essential elements that make up a crime. If used as a preventative method, the theory provides a framework where within it at least one of the elements needed for the crime can be altered. However, strategies that are more effective focus on all three of the elements (State of New South Wales, 2011).

2.2.2 Crime Pattern Theory

Crime pattern theory investigates local crime patterns and evaluates how people interact with their environment, leading to higher or lower levels of crime opportunity, in order to explain the spatial distribution of crime (Felson & Clarke, 1998; GÖK, 2011). This theory consists of three concepts (Felson & Clarke, 1998):

- Nodes refer to where people travel to or from, for example, school shopping malls and home.
- Paths refer to paths (streets, footpaths, etc.) that people take on a daily basis, these paths correlate with where people fall victims to crime.
- Edges refer to the boundaries of areas that people live or work in.

Offenders continuously search for targets around their personal activity nodes and the paths between them, although certain crimes are more likely to occur on the edges (Felson & Clarke, 1998; GÖK, 2011).

2.2.3 The Rational Choice Theory

It tries to see the world form the offender's point of view. "*It seeks to understand how the offender makes crime choices, driven by a particular motive within a specific setting, which offers the opportunities to satisfy that motive.*" This theory has the imagination of an offender that thinks before he acts even if it is just for a moment. He therefore, takes into account the cost (punishment) and benefits (rewards) of the crime, in most cases the immediate situation is judged and the long-term costs are neglected (Scott, 2000; Felson & Clarke, 1998).

While many criminological theories try to explain why some people have the tendency to become involved in crime, these theories focus on situational variables and how they affect a criminal's decision-making process rather than on the background of the offender. All three these theories explained above are formulated on the basis of situational crime prevention (Clarke, 2013).

Situational prevention comprises opportunity-reducing measures that (Felson & Clarke, 1998; Clarke, 1997):

- Are directed at highly specific forms of crime
- Involve the management, design or manipulation of the immediate environment in the most systematic and permanent way possible
- Make crime more difficult and risky, or less rewarding and excusable as judged by a wide range of offenders.

Situational crime prevention focuses on the settings for crime and not on the criminal himself, for example, burglar alarms, guard dogs/geese, security lights and "No Trespassing" signs. The idea of this theory is that if the opportunity for crime is reduced, crime rates will drop and *vice versa* (Anderson & McCall, 2005; Felson & Clarke, 1998; Clarke, 1997).

It can be said that the situational crime prevention theory, which forms the basis of the other three theories, is not interested in a criminal's profile or why criminals commit crime but rather which conditions are necessary for a crime to be committed. One of the sub-objectives of this study is to identify internal and external variables affecting the occurrence of livestock theft in the Free State Province. Therefore, situational crime theory can relate to this study if variables necessary for a crime to be committed could be identified and altered by means of control methods or management practices to make the crime (livestock theft) less attractive. When reviewing relevant literature it will be important to identify known internal and external variables affecting livestock theft as well as the control practices used to mitigate stock theft.

2.3 Stock theft legislation in South Africa

Despite excellent livestock theft legislation put in place to prevent livestock theft in South Africa, it still occurs (Kruger, 2014). The South African Stock Theft Act 57 of 1959 defines the different forms and types of livestock theft. However, the definition that will best suit this study is regulation four that defines stock theft as the act of entering any area of land closed off with sufficient fencing, kraal, shed stable or other walled place with the intent of stealing any stock on or within this area (Department of Justice, South Africa, 1959: 2).

Stock according to the Stock Theft Act means "*any horse, mule, ass, bull, cow, ox, heifer, calf, sheep, goat, pig, poultry, domesticated ostrich, domesticated game or the carcass or portion of the carcass of any such stock*" (Department of Justice, South Africa, 1959:2). A sufficient fence according to the law is defined as *"(means) any wire fence, or any other fence, wall or hedge through which no stock could pass without breaking it, or any natural boundary through or across which no sheep would ordinarily pass*" (Department of Justice, South Africa, 1959:2).

Persons found guilty for committing livestock theft in a districts court will be sentenced to a minimum of 6 months or a maximum of 3 years (Bothma, 2014). Cases of higher value will be referred to the regional court where maximum imprisonment of 15 years can be imposed. In extreme cases the case may be referred to the high court that has no limit on sentencing. The length of the period to be served depends on a few factors, including: the number of animals stolen, the worth of the animals, the criminal's track record and whether the animals were retrieved or not. Larger numbers of animals or animals with higher values will lead to longer imprisonment. Criminals with previous convictions will also receive longer sentences. If all of the stolen animals were recovered, a shorter period of imprisonment could be given and *vice versa* (Bothma, 2014).

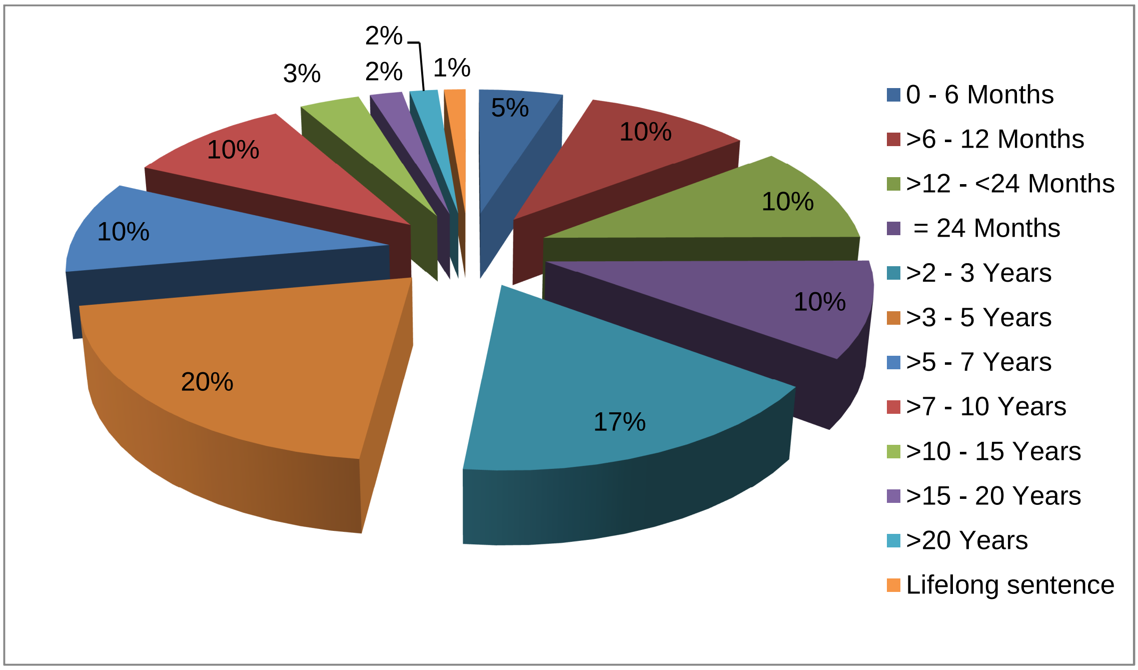


Figure 2.1: Sentences given to livestock thieves

Source: RPO (2012c)

Approximately 20% of stock theft thieves found to be guilty received a sentence of three to five years (Figure 2.1) (RPO, 2012c), approximately 17% of thieves received a sentence of two to three years. Lifelong sentences account for just more than one per cent and sentences of more than 20 years contributes approximately 1.6%. There are specific reasons for this, normally a combination of factors e.g. reoffender of a crime or other more aggressive crimes such as robbery, murder or assault is involved. More than 77% of the criminals (livestock thieves) were caught in four of the South African provinces namely: the Free State, Eastern Cape, Kwa-Zulu Natal and Mpumulanga (RPO, 2012c).

2.4 Cases of livestock theft worldwide

Stock theft is as old as the human race and has always been a problem to communities worldwide (Clack, 2013). The topic of stock theft has been investigated by researchers from other countries, for example: Anderson (1986), Cheserek *et al.,* (2012) and Bunei *et al*., (2013) from Kenya; Olowa (2010) from Nigeria; Khoabane & Black (2012) from Lesotho; Anderson & McCall (2005) from America and Barclay & Donnermeyer (2001) from Australia.

2.4.1 Kenya

Livestock theft in Kenya seems to become a more violent and organized crime. According to Anderson (1986) a transformation of livestock theft from traditional raids to organised crime can be seen in Kenya. A moral economic approach was used to investigate why these trends were seen and it was concluded that colonial legislation and an evolving colonial economy helped in this transformation. Cheserek *et al.,* (2012) investigated the factors that contributed to the changing of cattle raiding (herd men are scared away and their animals stolen without violence) to cattle rustling (the act of forcefully raiding livestock using guns and destroying property) after 1990. A social science research approach was used to identify the factors that caused the harsher violence as well as the socio-economic effect of these raids. Availability of guns, commercialization of cattle raids and political incitement were the three main contributing factors, with the availability of guns being the main reason. Recommendations made by the study to alleviate this problem include the building of schools, roads and markets in order to provide an alternative option to pastoralism. Fleisher (1998) investigated the trend in livestock theft where cattle are stolen and either sold to be butchered in Tanzania or driven across the border to Kenya where the market for meat is greater and the price is higher. Three complicated factors were identified why individuals will not likely oppose livestock theft in their area (Fleisher, 1998):

- Cattle raiding form an important part of their villages' economy and many individuals benefit directly or indirectly from these raids.
- Raids provide scarce and valuable sources of protein.
- Cattle raiding are seen as legitimate due to the continuing war between clans.

Factors influencing farm crime in Kenya was identified by Bunei *et al*., (2013). These authors found that 45% of all the farmers in the study have been victims of livestock theft. Almost 90% of the time livestock theft occurred at night and demographic factors associated with farm crimes were young people, people with low levels of education and seasonal workers. Farms closer to urban areas experienced higher levels of stock theft because livestock can easily be transported to nearby butchers and then little or no evidence is left for investigation.

Farm size also influenced the level of livestock theft with larger farms experiencing more stock theft than smaller farms Bunei *et al.,* (2013). Methods that were prescribed to the government to improve the farm crime level were:

- to enforce the minimum wage limits of farm workers
- to improve education levels and made more affordable to the community

Guidelines given to farmers to lower the occurrence of farm crime were as follows: treat farm workers fair and just, reward employees who report crime, keep proper records, improve farm security, taking out insurance to lower risk and form a community watch or similar community policing actions.

2.4.2 Lesotho

Khoabane & Black (2012) used a Standard household utility function to illustrate the impact of livestock theft in Lesotho. Results show that the effect of stock theft in Lesotho is not limited to just animals being lost by farmers but also causes lower consumption levels of animal products in the household and impoverishment of the livestock farmers. As the livestock farmers become poorer, their ability to invest in human capital and ability to cope with health problems is reduced. Results from this study indicate that stock theft is largely caused by poverty among the unemployed and drought-stricken crop farmers. Findings of Dzimba & Matooane (2005) concurred with that of Khoabane & Black (2012), that stock theft in Lesotho is mainly caused by unemployment. The literature showed that stock theft is increasing and becoming more violent in Lesotho as in the case of Kenya as stated by Anderson (1986) and Cheserek *et al*., (2012). Dzimba & Matooane (2005) did however, also identify strategies used to combat stock theft and factors contributing to the high occurrence of stock theft and slow prosecution rate of stock thieves. The factors that lead to slower prosecutions included corruption, slow response from police and a long investigation time. Actions taken to prevent crime consisted of neighbourhood watches, stock theft associations, police patrols and joint police/army patrols. Police patrols proved to have a significant effect on the rate of stock theft and the best results were obtained when these patrols work in consultation with community policing actions. The method used to gather data consisted of personal interviews with different role players in the communities (Dzimba & Matooane, 2005).

Another study that focused on Lesotho was done by Kynoch & Ulicki (2000) who investigated the impact of stock theft by means of completing a questionnaire during personal interviews. It was found that approximately 90% of households' economic situations have been negatively affected by stock theft and in years with a poor harvest, the rate of stock theft increased.

2.4.3 Nigeria

A Standard household utility function was also used in Nigeria by Olowa, (2010) to illustrate the effect of livestock theft. Similar results to that of Khoabane & Black (2012) in Lesotho was found. The effect of stock theft in Nigeria does not stop at the lost animals, it also causes lower consumption levels of animal proteins, impoverishment of the livestock farmers leading to a lower ability to invest in human capital and deal with health problems. Livestock theft in Nigeria is also caused by poverty among the unemployed and drought-stricken crop farmers (Olowa, 2010).

2.4.4 Australia

In New South Wales, Australia, Barclay & Donnermeyer (2001) used a place-based perspective to evaluate several types of agricultural crimes (including stock theft). It was found that 29% of the farmers in the study have experienced livestock theft in their farming careers. The relationship between these farm crimes, physical deterrence factors and precautionary measures undertaken by individual farmers were also evaluated. Topographic factors that proved to have an effect on the occurrence of livestock theft were:

- distance from the nearest town
- amount of hills on the farm

Control practices that proved to lower the occurrence of stock theft were:

- locking loading ramps
- keeping animals in paddocks close to the main house and away from the roads

Results indicate that the precautionary measures taken by the representing farmers were reactive and not proactive actions.

Crime prevention strategies applied by farmers in Australia include (Anderson & McCall, 2005):

- locks on barns and sheds
- guard dogs/geese
- regular meetings with police
- alarms
- closed circuit television (CCTV)
- animal identification devices

Farmers are more likely to have crime prevention strategies in place if they feel that the community is annoyed with the level of crime in the area, they feel that the level of crime is increasing in the community, the farmer is staying on the farm and lastly if the farmer is aware of published crime prevention material (Anderson & McCall, 2005).

2.4.5 America

The crime rate in America has seen an increase in recent years and this increase is not limited to urban areas but has also influenced rural areas. Farm crime rates (including livestock theft) have risen and it is expected to continue rising in the future (Dumkelberger, Clayton, Myrick & Lyles, 2002). Livestock theft annually cause approximately 20$ million (R200 million) in losses to farmers in the US with a recovery rate of 17% (Muhammad, 2002). The study of Dumkelberger *et al*., (2002) used social surveys to identify different kinds of crime experienced on farms, determine the opinions of the farm operators, identified practices used by farm operators to protect their property and to create an idea of the opinions of the farmers towards crime trends, law enforcement and crime prevention in rural areas. It was found that 16% of all respondents have been a victim of livestock theft in their farming careers. Livestock theft control methods identified by the authors are:

- branding the animals
- using ear tags
- notches in animals' ears
- other forms of livestock identifications
- keeping farm gates locked
- taking out livestock theft insurance
- having a neighbourhood watch during a farmer's absence

It was concluded that the solution to farm crimes does not lie in harsher or longer prison punishments but rather in more efficient on-farm preventions. The most efficient way to reduce the risk of farm crime is to make farm property less vulnerable.

2.4.6 Eritrea

The adoption rate of livestock insurance by Eritrean farmers was researched by Mohammed & Ortmann (2005). It was found that the level of formal education by the farmer, family size, farm size and information on the importance of livestock insurance are all positively correlated with the purchasing rate of livestock insurance. Off-farm investments, debt to asset ratio, number of years farming experience and diversification of farm enterprises are negatively correlated with the adoption rate of livestock insurance.

When reviewing the available literature on livestock theft, certain trends in livestock theft seem to come to light:

- The violence associated with livestock theft seems to be increasing.

- In some cases livestock thieves have formed syndicates that lead to higher numbers of animals being stolen at a time.
- Unemployment and low levels of education lead to higher livestock theft occurrences.
- It is not only the farmer that is affected by livestock theft but the farmers' community as a whole.

A wider range of loss controlling practices are identified that is being used around the globe. These practices include physical barriers used (locking of gates), animals (geese/guard dogs), management practices (tattooing and branding), technologies (alarms and CCTV) and actions taken against livestock theft (neighbourhood watch).

2.5 Factors affecting stock theft

During an investigation of the literature available on livestock theft and the control of livestock theft, different factors were identified that affected the occurrence of livestock theft. Two main types of factors can be identified from the findings. Figure 2.2 illustrates the two main types of factors as well as the sub-groups of factors falling under each of the two main groups.

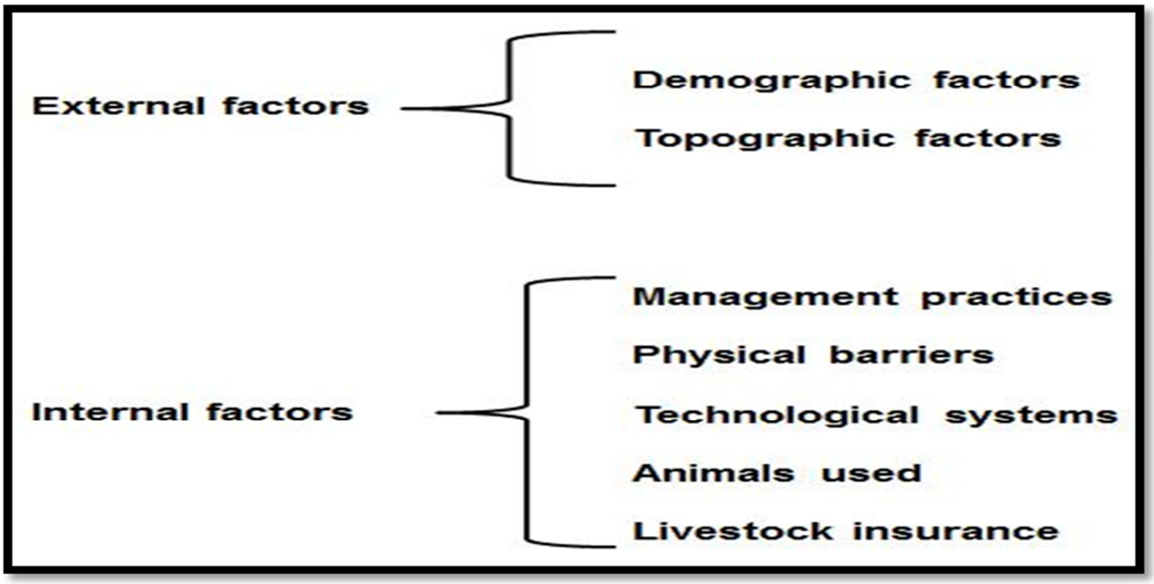


Figure 2.2: Classifications used for factors

The classification used to place factors in a suitable category is represented in Figure 2.2. External factors include variables that the farmer has little or no control over and identified external factors can be divided into demographic factors (2.5.1) and topographic factors (2.5.2). Demographic factors include variables such as the ratio of women to men and topographic factors include farm size and distance from town. Internal factors include the variables that a farmer can control and include: Management practices for stock theft prevention and detection (2.5.3), Physical barriers for stock theft prevention and detection (2.5.4), Technological systems for stock theft prevention and detection (2.5.5), Animals used for stock theft prevention and detection (2.5.6) and Livestock insurance in South Africa (2.5.7).

In the next part of this chapter the identified external factors and the manner in which each factor affects livestock theft will be discussed. The impact of stock theft does not stop at the direct economic losses to livestock owners; it also causes production costs to increase. One part of the production costs are the measures taken to lower stock theft or the indirect costs. A considerable amount of time and effort is invested in security measures to prevent stock theft. If production costs increase it will eventually lead to higher food prices. (KwaZulu-Natal Department of Community Safety & Liaison, 2008: 16).

Following the external factors the focus shifts to internal factors which include measures put in place and actions taken by farmers to prevent and detect livestock theft. These factors originate from studies throughout the world and it is not expected that all of these factors will influence livestock theft in the same manner as in the country of origin. It should, however, give a good indication of what results could be expected.

2.5.1 External factors affecting livestock theft

2.5.1.1 Demographic factors affecting stock theft

Demographic factors proven to affect livestock theft are shown in Table 2.1. Demographic factors found to be positively correlated with livestock theft are: drug related crimes, economically active proportion of the population, unemployment rate, proportion of population aged 15-35 years and expenditure on protection services as % of GDP. Higher occurrence of drug-related crimes increases the occurrence of stock theft. As the economically active proportion of the population increased the occurrence of stock theft increased. The occurrence of livestock theft increased as the unemployment rate increased. Where larger parts of a population were between the ages 15-35 years old, livestock theft increased. As the expenditure on protection services as % of GDP increased, the occurrence of livestock theft increased. Income per capita, the ratio of women to men and the degree of urbanization were identified as demographic factors negatively correlated with livestock theft. As the income per capita increased in an area the occurrences of stock theft decreased. Higher ratios of women to men in an area correlated with lower stock theft occurrences. Lower levels of urbanization lead to higher levels of livestock theft.

One explanation for the increase in stock theft as the expenditure on protection services as % of GDP increased could be the fact that national expenditure was used for all provinces (Blackmore, 2003). The increase in livestock theft when the economically active proportion of the economy increases, could be based on the fact that livestock theft mainly occurs in less populated areas, and as urbanization occurs the incidences of livestock theft are expected to increase due the relatively fewer people living in the rural area, given the probability of being caught is reduced together with the rural population (Blackmore, 2003).

Table 2.1: Demographic factors affecting livestock theft

Factor	Manner in which the factor influence livestock theft
Income per capita	As income per capita decreases the rate of stock theft increases.
Drug-related crime rate	Stock theft rates increased with increases in drug related crime rates.
Ratio of women to men	Higher ratios of women to men in an area showed lower occurrence rates of stock theft.
Economically active proportion of population	Bigger proportions of the population active in the economy showed an increase in stock theft.
Degree of urbanization	As the level of urbanization increased, stock theft decreased.
Unemployment rate	Higher unemployment rates lead to higher levels of stock theft.
Proportion of population aged 15-35 years	A larger proportion of the population between 15-35 years of age leads to a higher level of stock theft.
Expenditure on protection services as % of GDP	As the expenditure on protection services as a percentage of GDP increased, the occurrence of stock theft increased.

Source: Blackmore, (2003); Dzimba & Matooane, (2005); Olowa, (2010); Khoabane & Black, (2012).

2.5.1.2 Topographic factors affecting stock theft

Topographic factors affecting the level of livestock theft experienced are presented in Table 2.2 and are: terrain type, size of the farm, the distance from highways, cover and distance form town. Interesting to see is that distance from town showed contradictory results in separate studies. Bunei *et al*., (2013) from Kenya found that farms closer to urban areas experience higher levels of stock theft. Barclay & Donnermeyer, (2001) from Australia found the opposite. The further away from town, higher the occurrence of stock theft. The results of Barclays & Donnermeyer (2001) could be an example of the buffer zone theory, where areas close to criminals' homes are less likely to experience crimes due to reduced anonymity (Le Comber, Rossmo, Hassan, Fuller & Beier, 2011). The size of a farm is positively related to the level of stock theft experienced, thus larger farms experienced more stock theft. Farms with more hills, (more hilly) experienced higher rates of stock theft. Lower levels of stock theft are experienced on farms bordering main roads. Denser cover on farms led to higher levels of stock theft.

Table 2.2: Topographic factors affecting livestock theft

Factor	Manner in which the factor influence livestock theft
Distance from town	Distance from town proved to both increase and decrease the likelihood that livestock theft will occur on a farm.
Terrain type	The type of terrain on the farm e.g. flat and hilly influences the occurrence of stock theft. Hilly terrain experience higher stock theft rates.
Size of the farm	The bigger the size of the farm the higher the level of stock theft.
Distance from highways	Properties bordering main roads showed lower levels of stock theft.
Cover	Farms with dense cover had higher levels of stock theft (e.g. bush veld).

Sources: Barclay & Donnermeyer, (2001); Bunei *et al*., (2013).

2.5.2 Internal factors affecting livestock theft

2.5.2.1 Management practices for stock theft prevention and detection

- **Branding/marking**

Legal marking (branding and tattooing) serves as the first line of defence against stock theft (Department of Agriculture, South Africa, 2008:1). Pastoral communities started to practice branding and over the years registers of brand marks were created. Even though the practices of branding or marking differ between countries, the methodology and orthodox nature of animal identification remains the same. The most common methods of animal branding/marking are (Rao, 2012):

- hot branding
- freeze branding
- tattooing

The use of legal marks has many advantages relevant to stock theft. It serves as visible deterrent, improves the recovery rate and proves ownership for more effective policing (Barclay & Donnermeyer, 2001; Dumkelberger *et al.,* 2002; Department of Agriculture, South Africa, 2008:9)

According to the Animal Identification Act, Act No.6 of 2002: 4, cattle must be marked at the age of six months, can be tattooed at the age of one month, can be branded at the age of six months and must be branded by the age of the pair of permanent incisors. Small stock must be marked by means of a tattoo in the ear and must be tattooed at the age of one month (Department of Justice, South Africa 2002: 4).

- **Record keeping**

It is of great importance to maintain a thorough livestock register. The register should be kept up to date and the totals should be checked by the farmer. All relevant detail should be committed to this register. Cigarette boxes and small pocketbooks should not be used for the purpose of record keeping. In cases where animals cannot be counted daily, they should at least be counted twice a week on irregular days (Barclay & Donnermeyer, 2001; Oosthuizen, 2012).

- **Community**

Farmers are encouraged to have good relationships with their neighbours and to look after their interests as well. Night drives (patrols) in the area and within paddocks will serve as a deterrent method. Livestock farmers are also encouraged to stay involved in or establish a neighbourhood or farm watch system in their area (Dumkelberger *et al*., 2002; Oosthuizen, 2012). Good communication systems between neighbouring farmers and security forces are advised. Nearnet Radio Systems can be used for this purpose (Oosthuizen, 2012).

- **Employees**

When reviewing applications of new employees, the previous employer should be contacted to verify the reason for dismissal. Enquiries should also be made at the SAPS to check for criminal records. A copy of each employee's identification documents (ID) should be kept on file. Under no circumstances should illegal immigrants be employed. These immigrants could be conveying information to thieves on the other side of the border or planning to steal livestock themselves. An informant system should be created amongst employees where informants are rewarded for valuable tips (Oosthuizen, 2012; Jonker, 2013).

- **Security Guards**

Bushmen/Koi/San people are employed by some livestock owners as shepherds and security guards and they prove to be very successful in this regard (Oosthuizen, 2012). The sole purpose of these guards is to ensure the safety of the animals. Usually these guards do not partake in the physical labour activities on the farm but rather sleep during the day and do their rounds at night.

- **Crime scene**

Livestock owners should report stock theft immediately when they are made aware of it. If the reporting of stock theft cases is delayed, the chance of success reduces. In cases where the farmer recovers the stolen animals himself, the investigating officer should be informed as soon as possible. When arriving on a crime scene there are a few things one should remember (Oosthuizen, 2012):

- It is important not to investigate the crime scene yourself. It should rather be secured so that valuable evidence is preserved.
- In cases where animals are stolen from a kraal, the remaining animals should be left in the kraal. This is to preserve clues which will be destroyed as soon as the animals leave the kraal.
- If tracks are found at the crime scene, it should be protected from the rain and wind. These tracks should not be followed by the farmer; he should rather wait for a police dog.
- Cut wires should not be tampered with before samples are taken. Cut chains and locks should be kept in safe-keeping.
- Clothing and unknown objects like broken lights and vehicle rails should not be touched. It could help the SAPS Forensic Laboratory with successfully sentencing of the criminal.
- Carcasses of slaughtered animals should not be moved before a meat sample is taken and the scene is photographed.

2.5.2.2 Physical barriers for stock theft prevention and detection

- Fences and gates should always be kept in immaculate state to protect the livestock. Fences must be checked on a regular basis, daily if possible. Holes in and under the fence must be repaired as soon as possible (Barclay & Donnermeyer, 2001; Oosthuizen, 2012). Gates should be kept locked to deter thieves (Dumkelberger *et al.*, 2002). Although electrical fences are expensive to erect, it can be very effective against stock theft.

- Alarms can be linked to the electrical fence to notify the farmer of breaks in the fence and reduces the detection time for stock theft (Oosthuizen, 2012).
- Kraaling or corralling the animals at night might also help to lower the occurrence of livestock theft (Strauss, 2010).
- Some commercial farmers have dug trenches around their farm in an effort to stop stock theft. This method is, however, very costly and not completely effective and is bad for the environment (KwaZulu-Natal Department of Community Safety & Liaison, 2008: 16).
- All gates and paddocks adjacent to the road should be locked and control over the keys should be strict (Oosthuizen, 2012).
- Kraals should be built as close to the house as possible away from the road and sheep can be kraaled at night to stop theft (Oosthuizen, 2012).

2.5.2.3 Technological systems for stock theft prevention and detection

- **Lamps**

Paraffin lamps can be lit at night and placed in paddocks. These lamps can also be used to illuminate kraals which will serve as a deterrent method. It is important that the lamps are managed by the farmer himself to maintain the element of deterrence. If the word spreads amongst employees that the lamps are unattended, and reaches prospective stock thieves, these lamps will be useless (Oosthuizen, 2012).

- **Goat Bells**

In some cases goat bells are used to scare of pot-slaughterers. These bells serve as an early warning system when the animals become restless or are chased (Oosthuizen, 2012).

- **Fauna Track**

It is a system that makes use of electronic markers that are implanted or fixed on animals' necks by means of collars. This marker transmits signals to the local control station and from there the data can be accessed from the internet. This system allows farmers to monitor and track animals form anywhere on the globe where there is internet (Fauna Track, 2013).

- **Agri-alert**

This system makes use of sensors fixed around an animal's neck and sends signals to the base station as soon as abnormal or unexpected behaviour occurs. The base tower then sends a SMS message to the cell phone of the farmer informing him of this behaviour (Agri- alert, 2013).

- **Celmax**

Celmax makes use of a device fixed around the neck of an animal and generates alarm calls on the farmer's phone when animals are behaving abnormally. This system serves as an early warning system to farmers during stock theft incidences and predator attacks. Because this system uses cell phone networks, there are no limitations on the working distance and a farmer can even be on holiday and still receive the warning calls (Celmax, 2013).

2.5.2.4 Animals used for stock theft prevention and detection

Certain types of dogs have good shepherd instincts and when raised together with small livestock they will automatically guard the herd. These dogs serve as a prevention method only to a certain extent and will not eliminate theft entirely. Examples of these dogs are the Anatolian Shepard dog that acts independently, prefer routines and are suspicious of new activity (Botha, 2006; Oosthuizen, 2012). Dogs can be tied up next to kraals at night where sheep are kept to serve as an alarm. Ostriches have been known to be a very good deterrent against stock thieves when they are placed in paddocks with livestock. "Tame" black wildebeest are also known to scare off potential intruders (Oosthuizen, 2012).

2.5.2.5 Livestock insurance in South Africa

South Africa is one of the few countries in Sub-Saharan Africa that offers agricultural insurance products. In developing countries the demand for agricultural insurance is low. One reason for this is the limited understanding of insurance benefits. Insurance is seen as a non-practicable investment which is paid for every month and claims are paid out infrequently. Farmers tend to be extremely aware of their production risks. At the same time they may seem to exhibit "cognitive failure" because they can underestimate the likelihood or severity of catastrophic events (Mahul & Stutley, 2010). When it comes to livestock insurance the value of animals covered has dramatically increased between 2004 and 2012 (Bester, 2013). Livestock insurance includes products such as theft, extreme weather conditions, fertility, accidental death, mortality and epidemic disease cover (Mahul & Stutley, 2010; Mutual and Federal, 2005).

- **Theft cover**

The monthly premium for theft cover will differ between farms and areas. Agents are sent to applicants of theft cover to evaluate the risk associated with the specific farm. Stock theft statistics of the area are also used to assist in the calculation of premiums. Factors on the farm, such as electric fencing, can reduce the premium by up to 50%. One must also remember that insurance companies have to carry the risk of these potential losses, so higher risk farms will pay higher premiums. Thus, farmers near the Lesotho border will have to pay a very high premium for theft cover because of the high theft risk along the border (Dumkelberger *et al.,* 2002; Mutual and Federal, 2005; Bester, 2013)

- **Accidental death cover**

It covers the loss resulting from the death or destruction of an insured animal (Mutual and Federal, 2005). Mortality is influenced by management to a considerable extent. Mortality cover will thus suffer when it is used by the highest-risk farmers (Mahul & Stutley, 2010).

- **Weather/Lightning cover**

This cover will cover losses caused by harsh weather conditions such as severe cold. Historic weather data is taken into account when an insurance company calculates the risk of a specific farm and the premium. Livestock can also be covered for death by lightning (Mutual and Federal, 2005; Bester, 2013: Interview).

- **Hijacking/ Transit cover**

It covers animals stolen while they are in transit (Mutual and Federal, 2005).

- **Fertility/impotence cover**

This type of cover is applicable to stud animals and covers the farmer when expensive stud animals become unable to fulfil their purpose for which they were bought (Mutual and Federal, 2005).

- **Disease cover**

Disease cover will enable a farmer to cover his losses when a disease has caused losses to his herd or flock. Farmers must be aware that certain diseases have to be insured for separately and do not fall under the basic form of disease cover (Mutual and Federal, 2005).

- **Age restrictions**

There are certain age restrictions for animals to be covered and premiums are based on mortality rates within the permitted age group, risk and administration margins. This type of insurance is generally expensive (Mutual and Federal, 2005; Mahul & Stutley, 2010).

- **Eritrean factors**

Factors affecting the adoption rate of livestock insurance by Eritrean farmers were explored by Mohammed and Ortmann (2005). Results from the study showed that the level of formal education by the farmer, family size, farm size and information on the importance of livestock insurance are all positively correlated with the purchasing rate of livestock insurance. Off-farm investments, debt to asset ratio, number of years farming experience and diversification of farm enterprises are negatively correlated with the adoption rate of livestock insurance.

2.6 Current livestock theft situation in South Africa

One of the prominent aspects of pre-colonial Xhosa warfare was cattle raiding (livestock theft). Raiders who returned with large numbers of animals were seen as heroes (Peires, 1994), and large numbers of these captured animals were slaughtered immediately for consumption. These raids can be dated back to as early as 1806 (Alberti, 1811 cited by Peires, 1994). Research and statistics indicate that livestock theft is still a major problem that affects both the commercial and emerging livestock sector (Khoabane & Black, 2012; PMG, 2010; Clack, 2013), in all nine provinces of South Africa (NSTPF, 2014).

A change in livestock theft trends can be seen with thefts intensified during the 1990's becoming more "commercialized", where instead of stealing 3 or 4 sheep at a time, thieves now load truckloads at a time (PMG, 2010; Clack, 2013). These trends can also be noticed in the South African Police Service's National Stock Theft Unit's stock theft statistics, indicating that stock theft has been increasing form 2004/05, while the number of cases reported have been declining since 2003/04. One should assume that the reason for this phenomenon is that livestock theft has become lucrative and is attracting crime syndicates (Clack, 2013).

According to Scholtz and Bester (2010) the official livestock theft number from the South African Police Service (SAPS) are significantly lower than the true losses experienced. One explanation to this occurrence could be the fact that not all livestock theft cases are reported to the SAPS. The percentage of non-reported stock theft cases rose from 60.1% in 2011 to 64.4% in 2013/14 (Statistics South Africa, 2012; Statistics South Africa, 2014a). Thus, the livestock theft problem might be much bigger than expected. In the past research on livestock theft has been neglected because of the relative small impact compared to other crimes in the country (Clack, 2013). However, in recent years livestock theft has started to receive more attention. An Inter Provincial Stock Theft Forum has been formed between Gauteng and the Free State (IPSTF, 2013) and the

Deputy Minister of Agriculture is considering the establishment of a national stock theft body to look into the growing stock theft problem (Cele, 2014).

The annual economic impact of livestock theft on the South African red meat industry (sheep, cattle and goats) for the year 2011/12 was estimated at R300 million (RPO, 2012a). This amount is far less than that of Clack (2013) who calculated the 2011/12 annual losses at approximately R487 million. The total cost of losses to the red meat sector further increased to approximately R514 million in 2013/14 (RPO, 2014). These values only represent the direct cost to the livestock industry while ignoring the indirect costs.

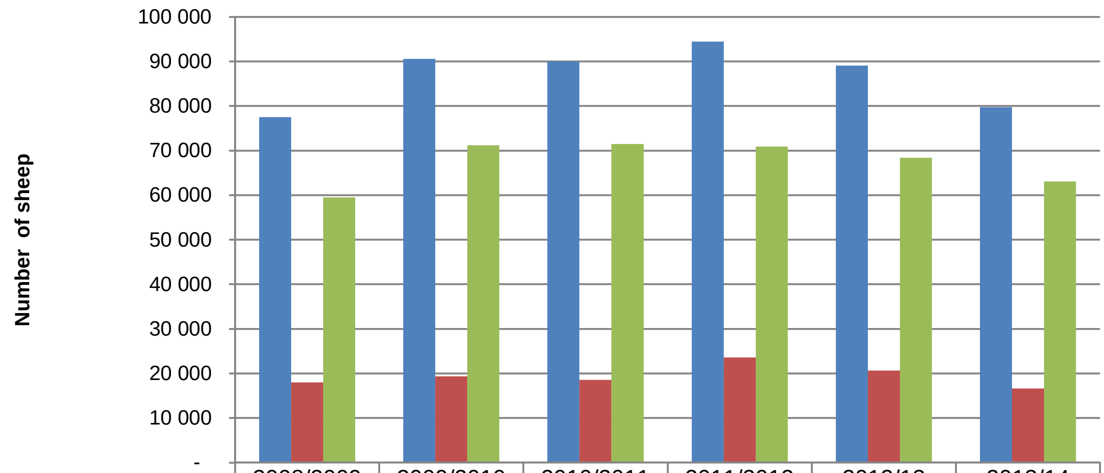
2.7 Livestock theft in South Africa

The focus in the next part of this chapter refers to South Africa's national and provincial livestock numbers and national livestock theft numbers according to official reports. Although the statistics of sheep, cattle and goats are shown and discussed, sheep are mainly focused on in this study.

2.7.1 National stock theft statistics

When looking at national statistics as illustrated in Figure 2.3, Figure 2.4, Figure 2.5, it can be deducted that the number of sheep, cattle and goats stolen has increased between the 2008/09 and 2010/11(NSTPF, 2014). The number of sheep stolen increased from 77 472 (2008/09) to 94 450 in 2011/12 and decreased to 79 713 in 2013/14. The same trend was followed by cattle where in 2008/09 59 432 animals were stolen; in 2011/12 69 011 cattle and even less in 2013/14 at 56 945. Goats stolen increased from 38 927 in 2008/09 to 40 078 in 2011/12 and decreased to 34 988 in 2013/14 (NSTPF, 2014).

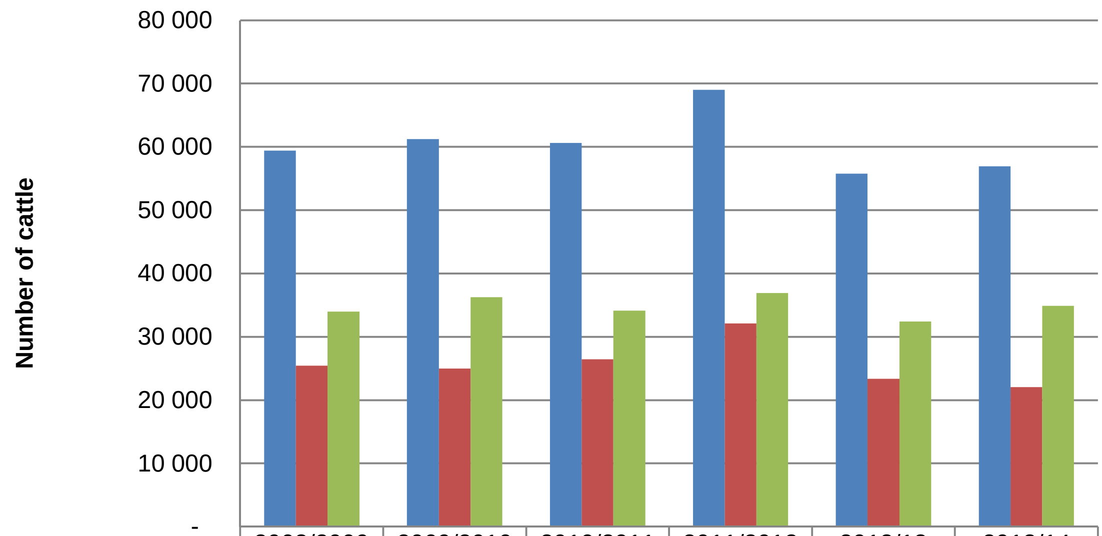
The success rate of recovering stolen sheep and goats appears worse than that of cattle. According to official statistics approximately 25% of stolen sheep were recovered, just more than 30% of stolen goats were recovered and almost 50% of stolen cattle were recovered during 2013/14 (NSTPF, 2014). The smaller body size of sheep and goats make them easier to handle and transport and therefore are more suitable targets for thieves (Sherry, 2012).



	2008/2009	2009/2010	2010/2011	2011/2012	2012/13	2013/14
Sheep stolen	77 472	90 540	90 017	94 450	89 100	79 713
Sheep recovered	17 973	19 355	18 541	23 569	20 679	16 663
Sheep losses	59 499	71 185	71 476	70 881	68 421	63 050

Figure 2.3: Number of sheep stolen and recovered between 2008/09 and 2013/14

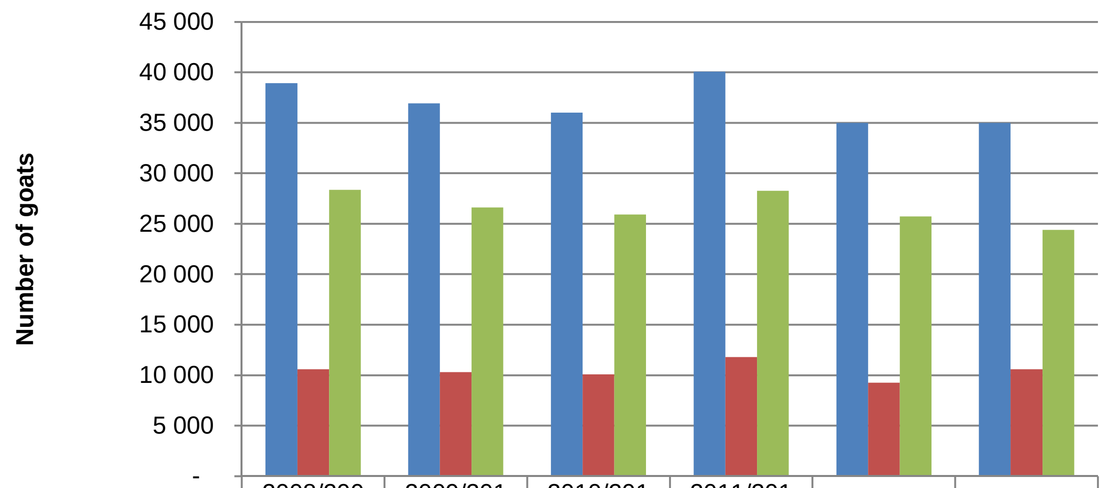
Source: NSTPF (2014).



	2008/2009	2009/2010	2010/2011	2011/2012	2012/13	2013/14
Cattle stolen	59 432	61 222	60 600	69 011	55 782	56 954
Cattle recovered	25 461	24 966	26 458	32 095	23 376	22 070
Cattle losses	33 971	36 256	34 142	36 916	32 406	34 884

Figure 2.4: Number of cattle stolen and recovered between 2008/09 and 2013/14

Source: NSTPF (2014).



	2008/2009	2009/2010	2010/2011	2011/2012	2012/13	2013/14
Goats stolen	38 927	36 927	35 995	40 078	34 989	34 988
Goats recovered	10 576	10 317	10 078	11 802	9 270	10 600
Goats losses	28 351	26 610	25 917	28 276	25 719	24 388

Year

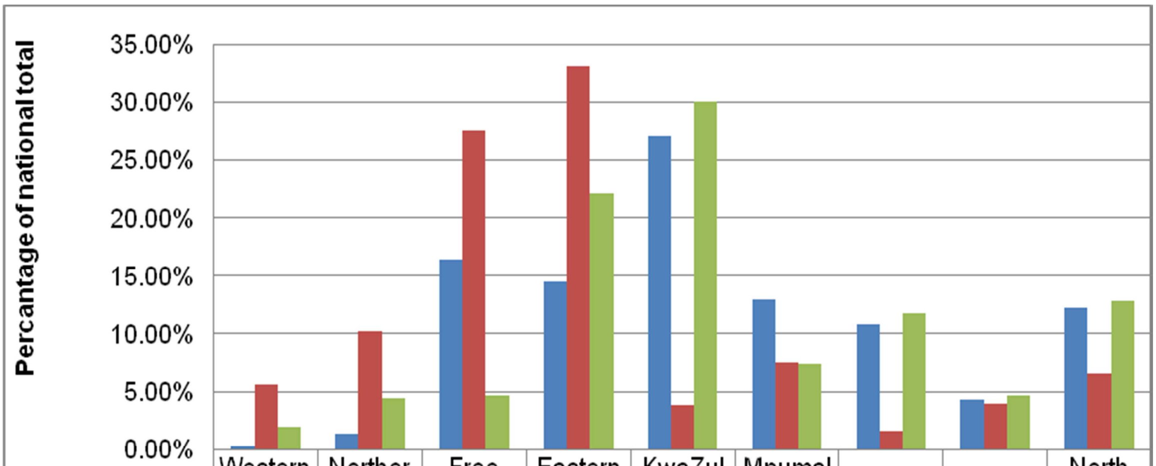
Figure 2.5: Number of goats stolen and recovered between 2008/09 and 2013/14
Source: NSTPF (2014).

The number of livestock theft cases reported decreased dramatically (39%) between 1994/95, when 47 287 cases were reported and 2004/05 when 28 742 cases were reported. Since 2004/05 up to 2013/14 the number of cases reported has seen a slight variations averaging between approximately 32 000 and 28 000 cases annually (South African Police Service, 2009; South African Police Service, 2014). This trend that the number of cases has been decreasing while the numbers of animals stolen are increasing, agrees with the statements made that livestock theft has become commercialized (Clack, 2013; PMG, 2010). Part of the variation in cases reported could be ascribed to the fact that not all stock theft cases are reported by victimised farmers. Between 2011 and 2013/14 the percentage of non-reported stock theft cases increased from 60.1% to 64.4% (Statistics South Africa, 2012; Statistics South Africa, 2014a). This trend in non-reporting of stock theft cases may be caused by different reasons. Many farmers do not report due to the lack of faith they have in the SAPS to retrieve the stolen livestock and to prosecute the case successfully. Victims use other methods to resolve the crimes and report to local authorities or neighbourhood watches. (Burton, Du Plessis, Leggett, Louw, Mistry & Van Vuurren, 2004; Singh, 2005; Statistics South Africa, 2012). In cases where animals are not properly marked in accordance with Section 7 of the Animal Identification Act No 6 of 2006, victims are afraid of receiving a fine if reporting the case and reclaiming of unidentified animals can be difficult (KwaZulu-Natal Department of Community Safety & Liaison, 2008; Clack, 2013).

Livestock theft numbers differ dramatically between provinces. In Figure 2.6 the number of sheep, cattle and goats stolen per province is given as a percentage of the national total of each species.

The provinces hit hardest by sheep thefts during 2013/14 in transcending order were: Eastern Cape (26 486), Free State (22 014) and the Northern Cape (8 179) (NSTPF, 2014). The province in which the largest number of cattle was stolen during 2013/14 was KwaZulu-Natal (15 430) followed by the Free State (9 347) and Eastern Cape (8 287). The largest number of goats was stolen in the Province of Kwazulu-Natal (10 534), Eastern Cape Province (7 731) and North West Province (4 512). Note the large portion of the stolen animals that originate from the Free State Province, Eastern Cape Province and Province of KwaZulu-Natal (NSTPF, 2014). Bear in mind that all three these provinces border Lesotho and that this high number of animals stolen could be the result of cross-border stock theft that intensified during the 1990's (PMG, 2010).

Recovery rate of stolen livestock for 2013/14 (Figure 2.7) differs between provinces, with the recovery rate of stolen sheep being lower than that of cattle and goats in all the provinces, except in Kwazulu-Natal and Mpumalanga. The highest recovery rate of sheep per province is that of Kwazulu-Natal (32.49%) and the lowest recovery rate occurred in Gauteng (14.76%).The recovery rate of stolen cattle was better than that of sheep and goats in all but two of the provinces (Northern Cape and Free State), with the highest recovery rate of cattle in the Western Cape (47.31%) and the lowest in Northern Cape (25.92%). On average the recovery rate of goats was higher than that of sheep and less than that of cattle. The province with the highest recovery rate for goats was the Free State (49.17%) and the province with the lowest recovery rate was Mpumalanga (19.25%) (NSTPF, 2014).



	Western Cape	Northern Cape	Free State	Eastern Cape	KwaZulu-Natal	Mpumalanga	Limpopo	Gauteng	North West
Cattle stolen	0.29%	1.29%	16.41%	14.55%	27.09%	12.95%	10.84%	4.35%	12.23%
Sheep stolen	5.57%	10.26%	27.62%	33.23%	3.80%	7.55%	1.54%	3.91%	6.52%
Goats stolen	1.87%	4.44%	4.65%	22.10%	30.11%	7.44%	11.83%	4.67%	12.90%

Province

Figure 2.6: Cattle, sheep and goats stolen per province as percentage of the national total
Source: NSTPF (2014).

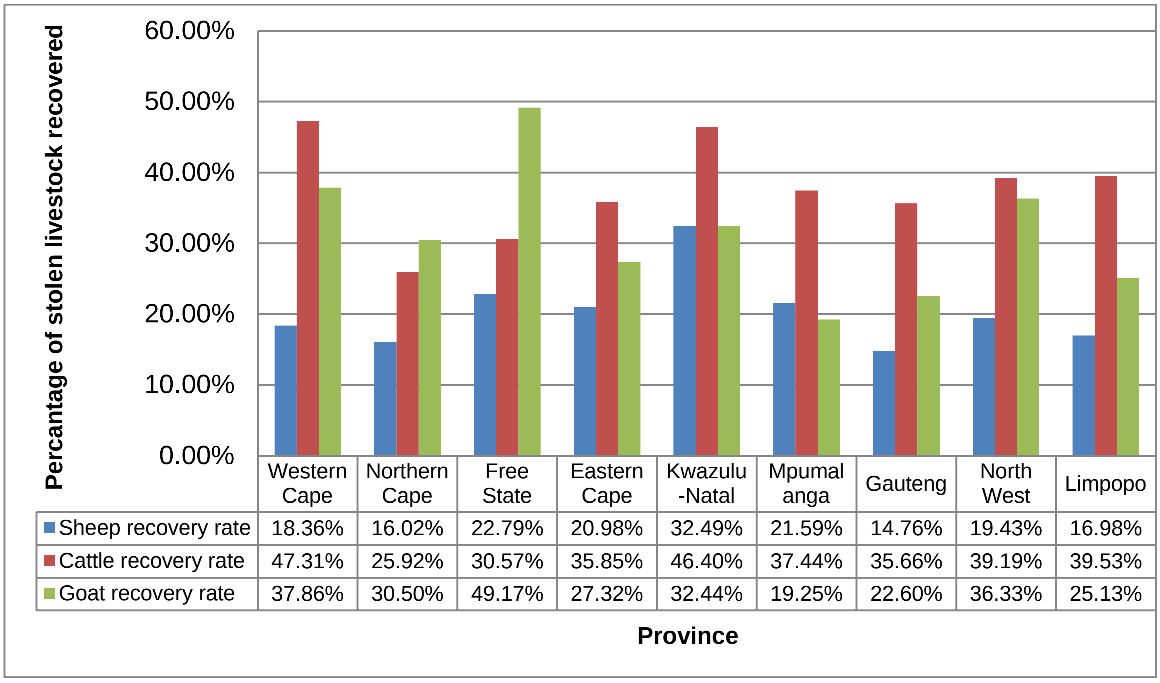


Figure 2.7: Percentage of stolen livestock recovered per province

Source: NSTPF (2014).

2.7.2 South African livestock numbers

In 2013 there were approximately 24.5 million sheep, 13.9 million cattle and 6.1 million goats in South Africa (Table 2.3). Sheep numbers have decreased from almost 29 million in 1996 to 24 million in 2012. Although cattle numbers have experienced slight increases and decreases between 1996 and 2012 it remained relatively stable at around 14 million during this period. The number of goats have shown slight variations during the same period but averaged around 6 million each year (DAFF, 2013c). The decrease in the number of sheep in the country may be caused by the fact that some farmers have left the sheep industry because of livestock theft (PMG, 2010). It can also be seen in Table 2.3 that the livestock numbers differ between provinces and species. This is caused by the difference in size of provinces and the percentage of land suitable for livestock grazing. In the Western and Eastern Cape Provinces, 80% of the land area is grazing land while only 20% of the land area in the Gauteng Province is grazing land (DAFF, 2013b).

The largest part of the national sheep flock originates from the Eastern Cape Province (28.82%) followed by the Northern Cape Province (25.21) and the Free State Province (19.38). In the case of cattle herds, the Eastern Cape Province (23.75%) houses the largest number of cattle, followed by Province of KwaZulu-Natal (19.95%) and the Free State Province (16.59%). The largest number of goats by far originates from the Eastern Cape Province (37.82%), in second place is Limpopo Province (19.31) and in third place the Province of Kwazulu-Natal (13.40%) (DAFF, 2013c).

Table 2.3: South African Livestock numbers

Type per province	Sheep	Percentage of national flock	Cattle	Percentage of national herd	Goats	Percentage of national flock
Western Cape	2 896 504	11.83%	563 416	4.05%	223 441	3.64%
Northern Cape	6 173 800	25.21%	500 628	3.60%	511 180	8.33%
Free State	4 746 516	19.38%	2 308 249	16.59%	240 251	3.92%
Eastern Cape	7 055 640	28.82%	3 304 677	23.75%	2 320 428	37.82%
KwaZulu-Natal	751 816	3.07%	2 775 640	19.95%	821 986	13.40%
Mpumalanga	1 815 359	7.41%	1 436 463	10.32%	89 174	1.45%
Limpopo	260 224	1.06%	1 047 858	7.53%	1 185 044	19.31%
Gauteng	97 458	0.40%	249 208	1.79%	41 178	0.67%
North West	688 276	2.81%	1 729 461	12.43%	703 453	11.46%
Total SA	**24 485 593**	**100%**	**13 915 600**	**100%**	**6 136 135**	**100%**

Source: Adapted from DAFF, 2013c.

2.7.3 South African research on stock theft

When comparing stock theft to other crimes in South Africa it may seem like a minority crime. Because of this minority view, stock theft research on the topic has been neglected in the South African society. The impact however, of stock theft in South Africa is not understood correctly (Clack, 2013). During the 1990's livestock theft, including cross-border stock theft, intensified and farmers are no longer dealing only with thieves stealing 3 to 4 sheep but also syndicates who steal truckloads full of livestock at a time (PMG, 2010). From research and statistics it is clear that stock theft is a huge problem and affects both emerging and commercial farmers (PMG, 2010; Khoabane & Black, 2012; Clack, 2013). However, according to Clack (2013), research investigating the effect of stock theft on commercial farmers in South Africa is non-existing.

In old Xhosa warfare one of the prominent aspects was raiding cattle from the enemy. It was also considered legitimate to enter neighbouring chiefdoms to steal cattle. One of the surprising things in this culture is that cattle raiders who risked their lives to steal big numbers of cattle were regarded as heroes. The petty thieves on the other hand, were banished (Peires 1994). A study done on the Sand River catchment area in the Bushbuckridge region of the Limpopo Province showed that the average annual total removal rate of animals was 19.4%. In this study it was also found that it was not just the owners of livestock that benefitted from the animals, but also non-owners who benefitted from livestock in their community. Animals from households with fewer animals had major roles to fill. However, households with larger cattle herds positively correlated with more uses and goods received (Shackleton, Shackelton, Netshiluvhi & Mathabela, 2005).

Scholtz and Bester (2010) investigated the effects of stock theft and mortalities on the livestock industry of South Africa. In this study it was noticed that there is a difference in the number of cattle stolen in the study and the figure given by the South African Police Services (SAPS) National Stock Theft Unit. The numbers given by the SAPS Stock Theft Unit is much lower and the study concluded that the official stock theft numbers seem to be underestimated. National stock theft numbers and livestock values provided by the National Stock Theft Forum were used to investigate the extent of stock theft in South Africa by Clack (2013). Results from the study showed that the financial losses due to stock theft, excluding recovered animals, amount to R486 634 700 for the period 2011/12. The number of livestock theft cases reported to the police declined with almost one third (33%) from 1994/95 to 2011/12. Part of this decline in cases reported could be ascribed to the fact that non-reporting of cases by victims was standing at 60.1% in 2011 (Statistics South Africa, 2012). It is also important to note that the values used in the calculation are the direct monetary value and that the effect of future breeding values and genetics were not taken into account (Clack, 2013).

It was found that livestock theft was responsible for 12% of the losses in the Free State Province, 7% in the Eastern Cape Province, 3% in the Northern Cape Province, 27% in the Mpumalanga Province and 4% in the Western Cape Province (Van Niekerk, 2010). A similar study was done by Strauss (2010) and it was concluded that for the period 2003 to 2007 stock theft on average caused 6% of the annual financial losses on a sheep farm.

Pecenka (2011) investigated the mitigation of theft through gift-giving. The author states that the motivation for this work was a South African university administrator's successful effort to use gift-giving to lower the amount of livestock theft and agricultural production theft. Surprisingly in this study it was found that the level of theft increased with an increase in the transfer size (the size of the gift). In the conclusion it was stated that this study is not applicable to livestock theft because it does not take into account the effect of relationships.

2.8 Valuing losses and modelling cost

Economics is often qualified as the discipline that uses monetary units as measurement whereas other disciplines use physical units. This definition is however, too simplistic or even inappropriate. Economics is more concerned with making rational decisions/choices when deciding where to allocate scarce resources. Monetary units are not the primary concern of economics but rather a measuring tool in which different resources and goals can be compared with each other (Dijkhuizen, Huirne & Jalvingh, 1995; Otte & Chilonda, 2001).

Research on stock theft is limited. When determining techniques to be used for valuing stock theft losses, it is necessary to investigate research fields that have evoked more studies. . Two areas used for this study are animal health economics and predation studies. The concept underlying economic analysis consists of three major components (McInerney, 1987):

- People: People want certain products and are responsible for making choices.

- Products: Products include goods and services that satisfy the wants of the people.
- Resources: Resources represent the physical factors serving as the basis for generating products.

Diseases (or stock theft in this study) represent negative input to the process of converting resources to products (Dijkhuizen *et al.*, 1995; Otte & Chilonda, 2001).

Productivity is referred to as the efficiency of converting inputs into outputs and defined as the rate of output divided by the rate of input. In a livestock production system many kinds of inputs are used and several types of outputs are produced; thus, a common measuring unit will be desirable for comparison. Monetary units are mostly used to express the economic value of inputs and outputs in a commercial livestock system (Otte & Chilonda, 2001). Sheep farmers strive to minimize lamb losses per ewe (direct losses) caused by predators, theft and disease. On the other hand, farmers also strive to minimize husbandry costs, which include loss-preventing measures (indirect losses) (Moberly, White, Webbon, Baker & Harris, 2003; Strauss, 2010). If the only objective of a preventative measure is to reduce predation, then the optimal solution for a farmer will be a trade-off between lamb losses and the cost of preventative measures (Moberly *et al*., 2003).

Economics strive to deal with the “real value” of producing a product and the captured price does not always serve as a correct measure. The same concept is applicable to the “real cost” or “opportunity cost” of producing a product where the financial expenditure incurred for the production of a product is not an adequate representation (Dijkhuizen, Renkema & Stelwagen, 1991). The direct income losses of a sheep enterprise play a major role in the enterprise’s economy, the indirect financial losses caused by input costs are usually lacking. These indirect costs include expenses such as veterinary care, labour and lick (Strauss, 2010). Disease losses can also be divided into direct and indirect losses. Direct losses are caused by death of productive animals, lower feed conversion rations and a lower level of output production. Indirect losses are caused by cost incurred to avoid the disease, harm done to human well-being and suboptimal use of resources (eg. not allowed to sell in a certain market because of disease) (Otte & Chilonda, 2001).

When considering which modelling technique to use for animal disease and their control, there is a number of factors that will determine the techniques used, namely (Dijkhuizen *et al*., 1995):

- The nature of the problem
- Available resources (time, money and analytical tools)
- Available data on the problem

For example, in a case where the effect over time does not have to be taken in to account, the data available is simple and the degree of chance is low. A partial budgeting model would be the model of choice (Boehje & Eidman, 1984 cited by Dijkhuizen *et al*., 1995). In cases where the effect over time is needed, a cost benefit model will be the model of choice (James, 1987).

Further differences between models must be considered. Static models do not have time as a variable and can therefore not simulate or analyze the effect over time. Dynamic models on the other hand, do incorporate time as a variable. Deterministic models predict a definite quantity (e.g. live weight), whereas stochastic models deal with probability distributions and/or random elements (e.g. price performance). Optimization models determine the optimum solution given the objective function and restriction, where simulation models calculate the outcome of pre-defined sets of input variables (Dijkhuizen *et al*., 1995).

Losses in terms of disease can be classified under at least four different headings (McInerney, 1987):

- Type of losses: Type of losses distinguishes between the direct effect of losses on or within a herd, flock or production process and the indirect losses in the wider economy.
- Level of aggregation: Level of aggregation measures losses on a micro level (individual production unit), sector level, and community of national level.
- Valuation losses: Valuing of losses can be done in terms of financial value, where the effect is shown on the farmer's bank balance, or in economic terms. In economic terms the "real" value of losses in output to the economy has to be calculated and the resources used in loss prevention activities have to be taken into account.

- Loss measure: Loss measurements are divided into:
  - Expended costs incurred to avoid the effects of disease.
  - Output value losses caused by lower production.
  - Marginal losses caused by suboptimal performance of the livestock production process.

The data in the different classes will become relevant for different decision-making contexts (McInerney, 1987).

According to Dijkhuizen *et al.,* (1995) in modern livestock systems the controlling of costs is becoming critically important. One of the central questions that form part of the livestock disease economic analysis is: To what extent resources should be allocated to disease control while taking into account the losses that could be avoided by the action; and to what extent it will be cheaper to accept these losses. This answer can be asked on farm level or community level however, the answers will be different for each case (McInerney, 1987). The losses found on farm level will represent the 'private' cost of disease or the economic effects experienced by the farmer. Economic expenditure undertaken by the government in response to livestock disease is recorded as 'public' cost.

When attempting to calculate monetary losses (direct cost) there is no unique monetary unit that can be used. The simplest basis that can be used is to quote losses in financial terms (McInerney, 1987). In some studies the livestock losses were valued as output losses to a farm at point-of-sale. Moberly *et al.,* (2003) calculated the output (direct) losses of the farm by multiplying the value of a finished animal (lamb) by the average weight for the specific type of animal (lamb, ewe, etc.) and finally multiplied by the number of animals lost on a specific farm. To approximate values conveniently, the value of finished lambs were used instead of considering the value of animals as replacement stock. Other studies developed theories that can be used to calculate the cost of losses at point of loss. To calculate the value of an animal at point of death the value of an average animal at different stages of its life is plotted over time. The value could then be determined once animals' age at time of death is known (McInerney, 1987).

While the theories discussed mainly focus on the direct cost of losses, other studies have focused on both direct and indirect costs of losses. According to Otte and Chilonda (2001) the total cost of losses (TC) is the sum of the losses (L) (direct and indirect) and the expenditure on controlling losses (E). Assumptions for this model are that control cost will differ between production systems and in a given production system losses will decrease as control expenditure increases.

A loss avoidance function was suggested by McInerney (1991) cited by Tisdell (1995) mathematically notated as:

$$LA = A - f(E)$$

Where:
LA = losses avoided by taking action
A = losses if no loss controlling methods were put in place
E = expenditure on the control of losses

Tisdell (1995) adapted this function and expressed it as: B = f (E) so that benefits of controlling losses (B) is a function of the expenditure on controlling losses (E)
If only one disease is under consideration in this function the net benefits will be maximized when N = B - C it as it maximum.
Where:
N = net benefits
C = the cost of controlling losses
The necessary condition for this is that the expenditure on loss control should continue until it returns the last dollar spent (Tisdell, 1995).

2.8.1 Methods used to model the implications of actions taken to lower losses

The research-induced supply shift (K) parameter was used by Jones, Saunders & Balogh (2005) to illustrate the effect of research-induced production increasing technology on the supply function of a commodity (Figure 2.8). This method can be used to calculate the economic surplus of the technology used. Production increasing technology used cause the supply curve to increase S_0 to S_1. However, to reach higher output levels require additional production costs. Additional production costs include drenching and vaccination costs. Therefore, the true supply shift (K) from production increasing technology is from S_0 to S_2.

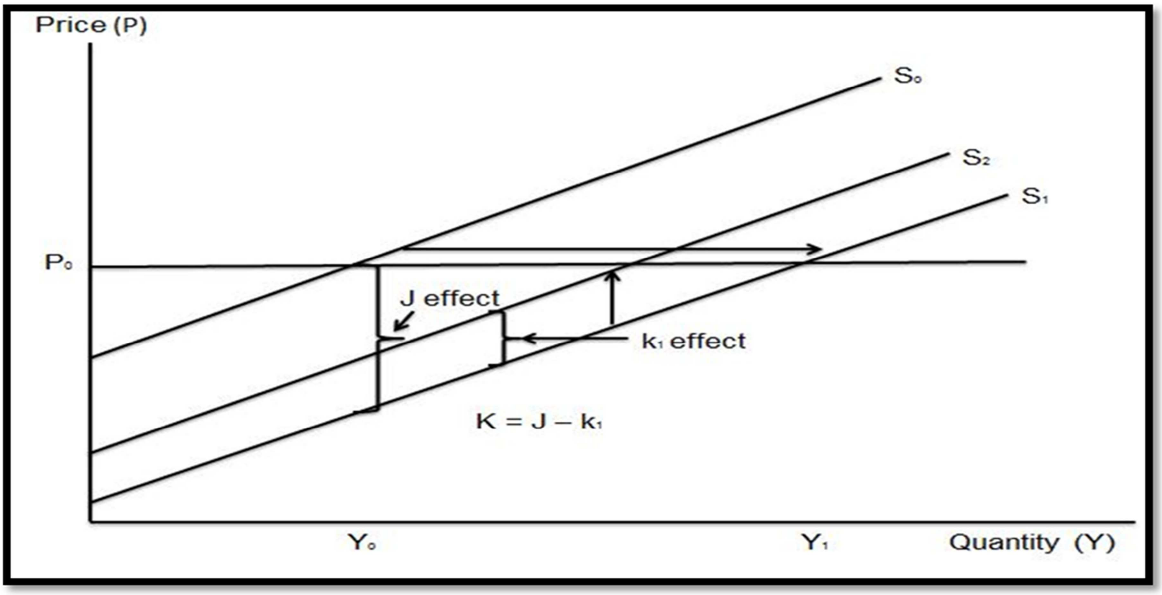


Figure 2.8: The effect of research-induced production increasing technology on the supply function of a commodity
Source: Jones *et al*., (2005)

The partial budgeting analysis can be used to investigate the economic implications of loss control actions taken. The analysis takes into account: the additional returns, reduced costs, returns lost and extra cost as a result of a change in loss-minimizing practices. If the result from the analysis indicate that the sum of the additional returns and the reduced cost are greater than the sum of the returns forgone and the extra costs the change should be implemented (Boehje & Eidman, 1984 cited by Dijkhuizen *et al*., 1995).

The cost-benefit analysis is very widely used and provided a consistent manner in which to evaluate decisions (Dreze & Stern, 1987). One of the advantages that a cost benefit analysis has over the partial budgeting method is that it takes into account the effect of time and acknowledges that a rand today is not worth the same as a rand tomorrow (Dijkhuizen *et al*., 1995; Mullins, Gerhrig, Mokaila, Mosaka, Mulder & van Dijk, 2002). A cost-benefits analysis works on the basis that the difference between the cost and benefits for each year of the project is calculated and discounted to the present (Mullins *et al*., 2002; Boadway, 2006). This method has been used by researchers such as Green, Woodruff & Tueller (1984), McLeod (1995) and Jones *et al*., (2005). McLeod (1995) compared traditional parasite control to strategic parasite control in Australia. This was done by comparing the costs (labour and chemicals) to animal losses due to parasites. Strategic parasite control proved to be economically worthwhile. Green *et al*., (1984) examined the cost and benefit of using guard dogs to protect livestock. Eighty per cent (80%) of the dogs in the study were considered to be economic assets. It was concluded that the loss-lowering strategies used in Jones *et al.,* (2005) had a benefit cost ratio (BCR) of 13.0:1 and should therefore be implemented.

2.9 Conclusion

Stock theft is one of the biggest problems faced by South African red meat producers (RPO, 2012b). While all nine of the provinces in South Africa experience livestock theft, some provinces are hit much harder than others. Three of the provinces that are affected more by livestock theft than the others are the Free State, Eastern Cape and KwaZulu-Natal (NSTPF, 2014). All three of these provinces border Lesotho and this large number of stolen animals could be the result of cross-border stock theft that intensified during the 1990's and became more widespread and organized (PMG, 2010). Because eighty per cent (80%) of the land in South Africa is mainly suitable for livestock farming (DAFF, 2012), research on livestock theft is of critical importance. It can however, be seen from available literature that:

- Research on stock theft in South Africa is limited.
- The number of animals lost seems to be underestimated in official numbers.
- Control methods against stock theft have not been thoroughly investigated as yet.
- Many factors affect the occurrence of livestock theft.

Research on stock theft is of national importance, not just for the country but also for the economically sustainability of the Red Meat producers of South Africa (Clack, 2013). Once the true number of losses is available the seriousness of livestock theft can be shown.

CHAPTER 3
DATA AND METHODOLOGY

3.1 Introduction

This chapter starts with an overview of the study area. The focus then moves to the sampling process and data collection of this study. Finally, the methods that will be used to reach the primary and sub-objectives are explained.

3.2 Study area

The Free State Province of South Africa, which is the focus of this study, is situated centrally within South African borders (Figure 3.1). The Free State Province is divided into five district municipalities namely: Fezile Dabi, Lejweleputswa, Mangaung, Thabo Mofutsanyane and Xhariep (Figure 3.2). The province does not only share its border with six other provinces, but also with Lesotho. Lesotho, also known as the Mountain Kingdom, is completely surrounded by South Africa (Lesotho, 2015). The border shared between the Free State Province and Lesotho is 450 km long and is guarded by 100 troops of the South African National Defence Force (SANDF) (Steinberg, 2005). The Free State Province has a population of 2 745 590 (Statistics South Africa, 2011a) with roughly 54 000 people employed in the agricultural sector of the province (Statistics South Africa, 2014). According to the Department of Agriculture, Forestry and Fisheries (DAFF) there are 6 065 commercial livestock farming units in the Free State Province (DAFF, 2013a).

The province has a total size of 12 943 700 ha, of which 90.9% is used for farming. Commercial farmers have approximately 11.5 million hectares of land to their disposal and emerging farmers almost 323 thousand hectares (DAFF, 2013a). Grazing land, which is mainly suitable for livestock farming, makes up 58.1% of commercial farmland and 66% of emerging farmland (DAFF, 2013a) The Free State Province has the third largest number of sheep as well as cattle estimated at approximately 4.8 million sheep and 2.3 million cattle respectively (DAFF, 2014a). A noticeable difference in terms of the Free State Provinces' sheep numbers can be seen between district municipalities (Figure 3.3). The Xhariep district municipality houses the largest percentage of the Free State Provinces' sheep at approximately 41% and the Mangaung district municipality houses only approximately 1% (DAFF, 2014a). Carrying capacity (Figure 3.4) differs dramatically throughout the province from 3.5 ha per large stock unit (LSU) in the East to 16 ha/LSU in the West (DAFF, 2014b).

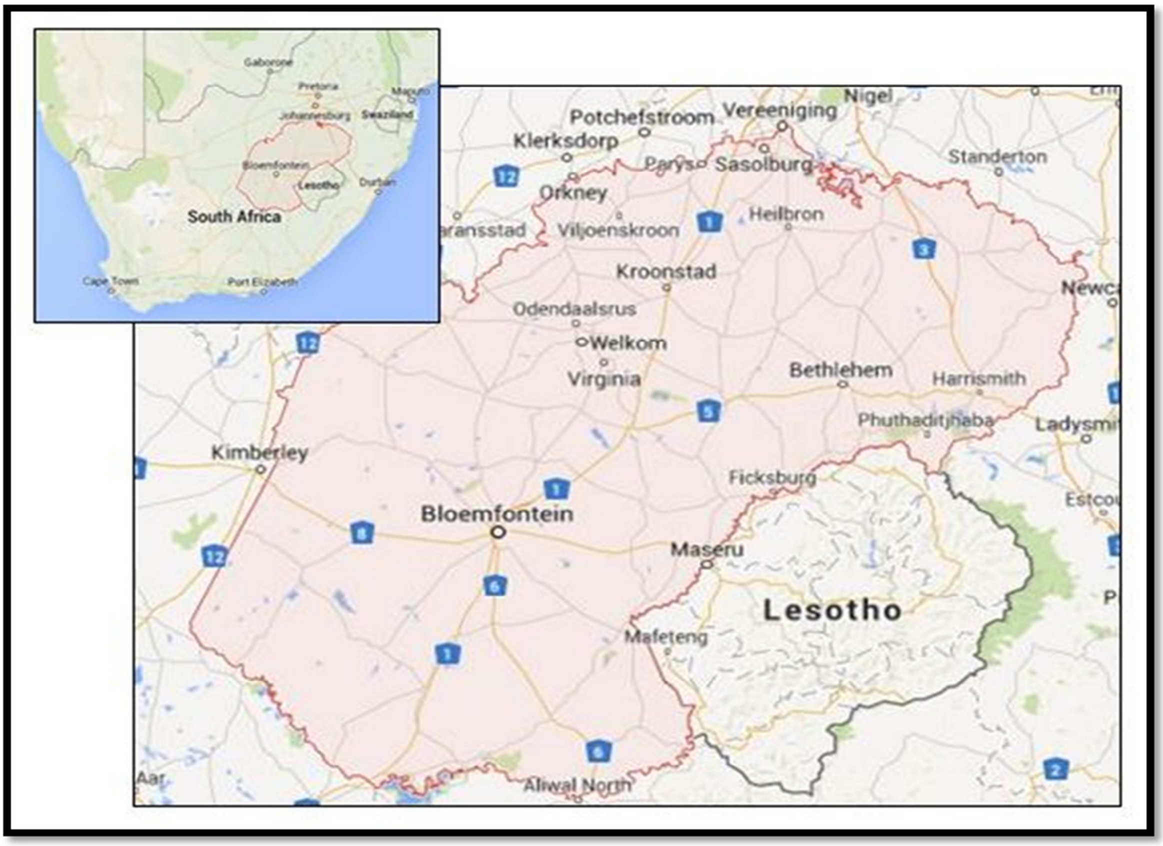


Figure 3.1: Geographical location of the Free State Province

Source: Google Maps (2015)

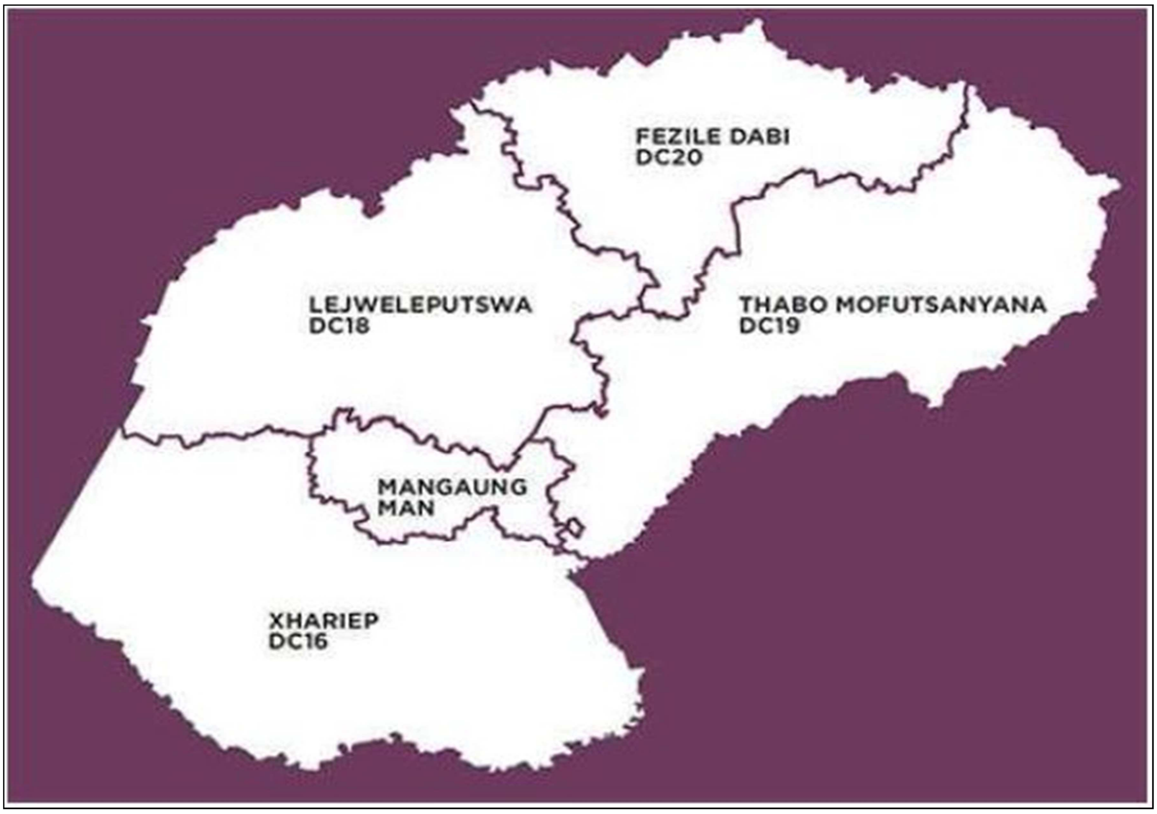


Figure 3.2: District municipalities of the Free State Province

Source: The Local Government Handbook (2015)

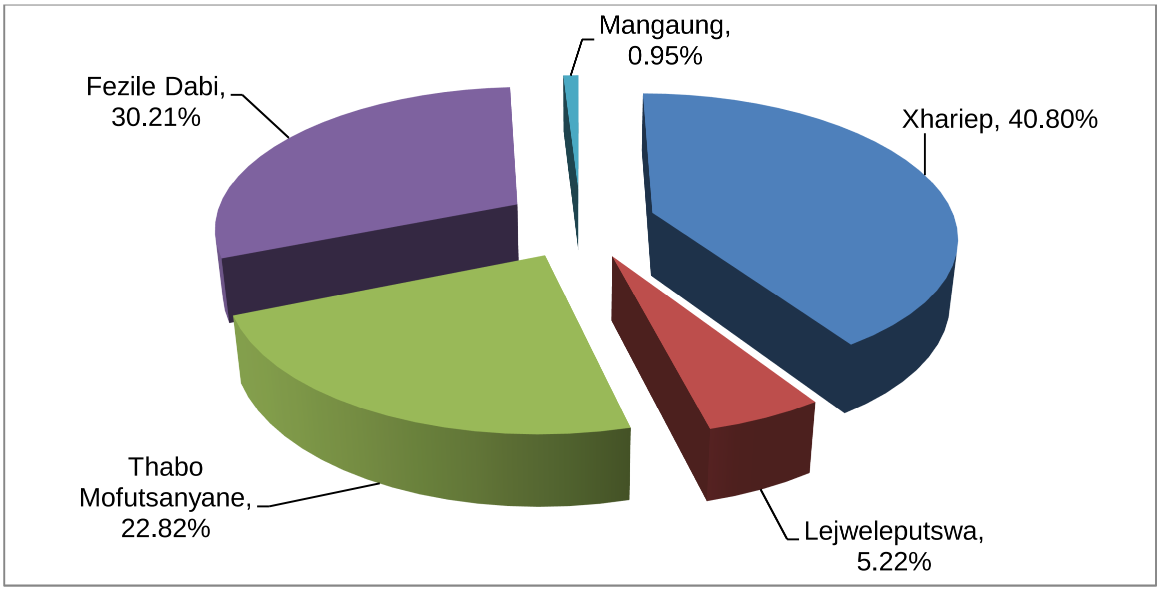


Figure 3.3: Distribution of sheep between district municipalities.

Source: DAFF (2014a)

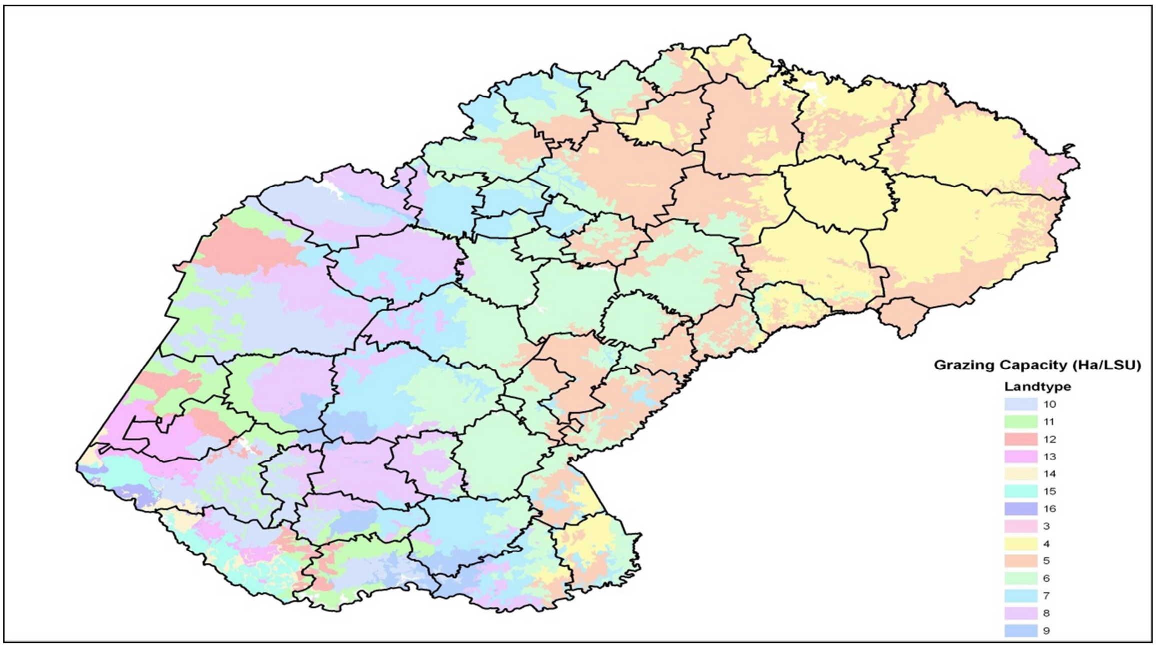


Figure 3.4: Grazing capacity map for the Free State Province

Source: DAFF (2014b)

3.3 Sampling

Research data can be collected by means of sampling, where a subset of the target population is used, or by means of census where the entire target population is selected (Daniel, 2012). When collecting data, researchers prefer to use a sample from a population rather than collecting data from the whole population. This is done to save time, money and other human resources. In some cases sampling has proven to be more reliable than collection data from the whole population (Cochran, 1977; Sekaran & Bougie, 2013). A sample is a subset of the population; for instance, out of a population of 1 000 members a sample size of 200 will be used. By studying the sample the researcher should be able to draw conclusions that are generalized to the specific population (Sekaran & Bougie, 2013). Population refers to the entire group of people or event of interest that the researcher wants to investigate. Individual persons and events within the population represent an individual element. The population can be grouped into sub-populations or strata (Feinberg, 2003).

3.3.1 Methods of Sampling

Methods of sampling consist of probability and non-probability sampling or a combination of the two (mixed-methods sample design). Probability sampling gives every element in the target population a known and nonzero chance of being selected. Non-probability sampling does not (Daniel, 2012). Probability sampling consists of simple random sampling, systematic sampling, cluster sampling and stratified random sampling (Daniel, 2012).

Simple random sampling is done by selecting the number of respondents required for the study out of the entire population. Each respondent has the same chance of being chosen and respondents will originate from anywhere in the population (Cochran, 1977). Systematic sampling is a probability sampling procedure where a random selection is made of the first element of the sample, and subsequent elements are then selected using a fixed or systematic interval. Cluster sampling is a probability sampling procedure in which elements of the population are randomly selected in naturally occurring groupings or clusters (Daniel, 2012). Stratified random sampling is where the population is divided into subpopulations; and random samples are then chosen from each subpopulation (Cochran, 1977; Feinberg, 2003) Reasons for using stratified random sampling includes (Cochran, 1977; Feinberg, 2003):

- Each of the subpopulations in the population is of interest and therefore estimates will be needed for each subpopulation.
- Different methods of sampling schemes may be suitable for different subpopulations.
- The population is geographically diverse and stratification is a convenient way of organizing the sampling and data collection.
- If stratification is employed correctly, the estimates will give us a more realistic representation of the population.

The need to choose the right sample for the research cannot be over-emphasized. The chances are very small that the sample will be an identical replica of the population. However, if the sample is scientifically chosen, the results should most probably be fairly close to the population parameters (Sekaran & Bougie, 2013). The larger the sample used in the study, the more accurate and closer the actual results will be to that of the entire population (Babbie, 2001). As stated by Bartlett, Kotrlik & Higgins (2001) a larger population will require a smaller percentage of respondents to be surveyed. According to Roscoe (1975) a sample size of 10 to 20 samples can be sufficient for research; however, it is recommended that a sample should consist of at least 30 samples. This rule is also applicable to subpopulations when comparisons are going to be made between subpopulations.

To calculate appropriate sample sizes for survey two formulas was developed by Cochran (1997), one for categorical data and one for continuous data. The sample sizes for categorical data are larger than that of continuous data (Bartlett, *et al.*, 2001). The questionnaire that was used collected both continuous and categorical data; thus, to ensure that the sample size is appropriate the calculation for categorical data will be used to calculate sample size and is expressed as Equation 3.1:

$$N_0 = (t)^2 * (p)(q) / (d)^2 \tag{3.1}$$

Where:

N_0 = sample size

t = value for the selected alpha level (indicates the level of risk the researcher is willing to take so that true margin of error may exceed the acceptable margin of error)

$(p)(q)$ = estimate of variance = 0.25 (maximum possible proportion (0.5)*1-maximum possible proportion (.5) produces maximum possible sample size)

d = acceptable margin of error for proportion being estimated = .05 (error researcher is willing to take) (Cochran, 1977; Bartlett *et al*., 2001).

If this formula is applied to the study and an alpha level of 1.65 (0.10), estimated variance of 0.5 and an error level of .05 were used, the formula would look as follow:

$$N_0 = (1.65)^2 * (0.5)(0.5) / (.05)^2 = 272 \tag{3.2}$$

resulting in a sample size of 272 respondents. Note that, if the sample size exceeds 5% of the population the correctional formula of Cochran (1977), expressed as Equation 3.3, should be used to calculate the final sample size (Bartlett*, et al.,* 2001):

$$N_1 = N_0 / (1 + N_0 / population) \tag{3.3}$$

Where :

N_0 = Sample size

N_1 = Final sample size

According to DAFF (2013a), there were 6 065 commercial livestock farming units in the Free State Province. Thus, 5% of this value will be 303. The correctional formula will not be necessary to use and a sample size of 272 should be sufficient for this study.

Surveys can be administered in a number of ways: telephonically, personally administered, postal or via email/internet (Dillman, 1998; MacDonald & Headlam, 2008; Schutt, 2011). Each method has its advantages and disadvantages. Telephonic administered interviews obtain information immediately and questions can be explored with respondents. This could however, be using more resources than other forms of surveys (MacDonald & Headlam, 2008). Postal surveys can reach a large geographic area and can be completed anytime and anywhere. However, respondents must be able to read and write and if the respondents are not motivated the response rate will be low (MacDonald & Headlam, 2008; Schutt, 2011). E-mail administered questionnaires can be distributed at a very low cost and links can be added to give additional explanations. It takes more or less the same effort from the respondent to complete an e-mailed survey than to complete a telephonic survey (Dillman, 1998). The success of e-mailed questionnaires depends on whether respondents have internet access and if respondents are computer literate, which might not always be the case. Personally administered surveys have more of less the same advantages and disadvantages than that of telephonic interviews (MacDonald & Headlam, 2008).

A stratified random sampling process will be followed for this study where livestock farmers within the Free State Province will be divided into different subpopulations within the province according to their farms' demographic and topographic location. This method of sampling was chosen so that comparison and correlation between the different subpopulations can be done. By following this method it also ensures that only livestock farmers will be interviewed. The questionnaire was administered to the selected farmers during a telephonic interview. Telephonic interviews were used because the data can be obtained immediately, it saves time and the answers can be explored while interviewing respondents (MacDonald & Headlam, 2008) Calculation of the sample size showed that 272 farmers will have to complete questionnaires to ensure that the data is representative. In total 292 farmers were willing to complete the questionnaire that was used to collect data for the study.

3.3.2 Subpopulations

From the literature reviewed it became clear that livestock theft rates were found to be correlated to topographic and demographic factors. It was therefore deemed important to also test for similar occurrences in this study. To reach the hypothesized objectives, responding farmers were divided into the following sub-populations according to the location of the farms:

- Farms close to large towns

- Farms close to small towns
- Farms close to the Lesotho border
- Farms close to informal settlements
- Farms close to livestock theft hotspots

To represent the large towns, the five biggest towns in the Free State Province were identified based on their population. These towns are: Bloemfontein, Botshabelo, Welkom, Sasolburg and Kroonstad (Statistics South Africa, 2011b). Note that neighbouring areas were taken into account to determine the size of the town. The remaining towns represented the small towns. To represent the towns close to the Lesotho border, the following towns were identified: Fouriesburg, Ficksburg, Ladybrand, Wepener, Vanstadensrus, Hobhouse, Zastron and Clarens. These towns are all closer than 40km to the Lesotho border. Hotspot town in terms of livestock theft for 2013 in the Free State Province were identified from SAPS crime statistics namely: Harrismith, Bethlehem, Selosesha (Botshabelo area), Phutaditjhaba and Vrede (South African Police Service, 2013). The distance that a farm is located from the nearest informal settlement will be identified during the survey.

3.4 Questionnaire development

A structured questionnaire was developed to obtain relevant information regarding livestock theft in the Free State Province. The questionnaire was designed to be administered during telephonic interviews. The questionnaire was designed based on the principals suggested by Moberly (2002) and on a questionnaire used by Van Niekerk (2010). The questionnaire included questions on farmers' years of farming, age, farm size, farm location and farm topography, losses due to livestock theft and practices used to control livestock theft. Questions of the practices used to control livestock theft included: methods used, actions taken, how often these practices are performed and the annual cost of these practices.

3.5 Data collection

The Red Meat Producers Organization (RPO) of the Free State Province provided a data set with contact details for approximately 2 500 livestock farmers in the Free State Province. This ensured that only livestock farmers were contacted. These farmers were divided into the different subpopulations and farmers were then randomly selected within each subpopulation. The number of farmers selected per subpopulation was based on the size of a subpopulation as a percentage of the total population. Selected farmers were telephonically contacted between May and August 2014. Most of the farmers were contacted during the late afternoon and early evening.

3.6 Practices applied to reach objectives

The major practices applied to reach the objectives of this study include the quantification of the direct and indirect financial cost of livestock theft in the Free State Province and an investigation of the factors affecting livestock theft.

3.6.1 Quantification of the direct and indirect costs of losses to livestock theft

The primary objective of this study is to quantify the economic impact of sheep theft in the Free State Province of South Africa. To calculate the total economic impact of sheep theft the direct and indirect cost are necessary.

3.6.1.1 Direct costs

Quantification of the direct cost will consist of two calculations. First, the total number of sheep lost annually in the Free State Province per district municipality will be calculated as follow:

$$L = R \times S \quad (3.4)$$

Where:

R = the annual loss rate per district municipality (%)[2]

S = the total number of sheep per district municipality

L = the total number of sheep lost annually per district municipality

The sheep lost annually per district will be added to calculate the total number of sheep lost annually in the Free State Province. Once the total losses are determined, the monetary value of the losses will be calculated as follow:

$$C = L \times P \quad (3.5)$$

Where:

L = the total number of sheep lost annually in the Free State Province

P = is the unit cost per animal

C = is the total annual direct cost of sheep theft in the Free State Province

To calculate the annual loss rate in the study, the number of animals stolen was taken and the animals retrieved was deducted to calculate the number of animals lost annually (not recovered by the police or by the farmers themselves). This number is then divided by the number of

[2] As calculated in Table 4.4.

animals represented in the survey and expressed as a percentage. This annual loss rate indicates the rate at which animals are lost annually.

To assign a monetary value to losses is difficult if animals are not at the point of sale (Van Niekerk, 2010); however, the National Livestock Theft Forum decided on a value of R1 700 per sheep during the RPO National Congress in 2012 (RPO, 2012b). One could argue that this value is an overestimation for all animals; however, this value will serve as a basis from which to work and could be changed for other analyses (Badenhorst, 2014).

3.6.1.2 Indirect costs

The indirect costs represent all of the expenses incurred in an attempt to control/lower sheep theft. Indirect costs will be calculated as follow:

$$M = T/N \tag{3.6}$$

Where:

M = the annual cost of control practices per sheep per district

T = the total annual cost of control practices per district in the survey

N = the number of sheep per district in the survey

Once the annual cost of control practices per sheep per district was known, the total cost of control practices per district could be calculated as follow:

$$K = M \times S \tag{3.7}$$

Where:

K = the total annual cost of control practices per district

M = the annual cost of control practices per sheep per district

S = the total number of sheep per district

To calculate the total indirect cost of livestock theft in the Free State Province, the total annual cost of control practices per district will be added.

The process of quantification used in this study is similar to that of Moberly (2002), Van Niekerk (2010) and Badenhorst (2014). In all of these studies the direct and indirect cost were calculated to represent the total cost of losses. Scholtz & Bester (2010) only calculated an annual loss rate (%) as will also be done in this study.

Livestock theft control practices will also be identified and the percentage of farmers using each method will be determined. Control practices were sub-divided into methods used and actions taken. Methods used include aspects such as: management practices, physical barriers, animals and technology, whereas actions taken include: night patrols and access control. The calculations for the indirect cost will be conducted for both methods used and actions taken.

3.6.2 Identifying factors affecting livestock theft

The third sub-objective of this study was to identify factors affecting the livestock theft in the Free State Province. Van Niekerk (2010) found that the factors affecting the occurrence of predation and the factors affecting the level of predation are not the same. Based on this it was hypothesised that the factors affecting the occurrence of livestock theft and factors affecting the level of livestock theft are not the same.

In this study the model on factors affecting livestock theft will cover two aspects: whether or not livestock theft will occur and if livestock theft occurs, what quantity (level or the number of animals) of livestock theft will occur. It should be noted that some farmers did not experience sheep theft during the period data was collected for; however, 71% of farmers experienced losses. Excluding zero observations from the data can lead to a sample that is biased as well as biased regression parameters. It is therefore, important to include zero observations in the estimations procedure (Aramyan, Oude Lansink & Verstegen, 2007). These zero observations should be included in the model, because it is possible that no sheep theft occurred during the three years that data was collected for, or that the stock theft control practices are of such nature that no losses were experienced. It is therefore important to include the zero observations when determining factors affecting sheep theft (Van Niekerk, 2010).

A model that is typically used to deal with zero as a common value for the dependent variable is the Tobit model (Tobin, 1958; Gujarati, 2003; Aramyan *et al*., 2007). The Tobit model is however, very restrictive, any variable that increased the probability of a livestock theft will also increase the quantity of livestock theft on a farm (Lin & Schmidt, 1984; Jordaan & Grové, 2010). Thus, the same variables will affect the probability that livestock theft will occur as well as the quantity of livestock theft.

An alternative for the Tobit is the Craggs model that allows for one set of parameters to determine the probability of livestock theft occurring and another set of parameters to determine the quantity of livestock theft (Lin, & Schmidt, 1984; Cragg, 1971). Cragg relaxes the assumption that the same variables and the same parameters vector affect both the occurrence of the dependent variable (is livestock theft experienced yes/no) and the level of the occurrence of the dependent variable (how much livestock theft is experienced) (Katchova & Miranda, 2004). Due to the fact that it is hypothesised that the variables affecting the occurrence of livestock theft and variables affecting the quantity of livestock theft are not the same, the Craggs model would be a more appropriate model for the study.

The Probit model will be used to model whether or not livestock theft occurred (yes/no) and the Truncated model will be used to measure the level (how much) of livestock theft experienced. According to Katchova & Miranda (2004) the Probit (3.7) and Truncated (3.8) models are represented as follow:

- Probit:

$$P(\alpha_i = 0) = \Phi(-\frac{\beta'_\alpha X_i}{\sigma}) \quad (3.8)$$

Where:

P = is the probability

α_i = quantity of livestock theft

$\Phi(.)$ = the standard normal probability density function

β_α = a vector of coefficients

X_i = variable or an $S \times 1$ vector of personal and farm characteristics for farmer *i*

σ = variance

- Truncated

$$f(\alpha_i|\alpha_i > 0) = \frac{f(\alpha_i)}{P(\alpha_i > 0)} = \frac{\frac{1}{\sigma}\phi(\frac{\alpha_i - \beta'_\alpha X_i}{\sigma})}{\Phi(\frac{\beta'_\alpha X_i}{\sigma})} \quad (3.9)$$

Where:

$f(.)$ = the probability density function

P = the probability

α_i = the density (quantity) for the positive values

$\Phi(.)$ = standard normal probability density function

β_α = a vector of coefficients

X_i = a variable or a $S \times 1$ vector of personal and farm characteristics for farmer *i.*

σ = variance

It is important to note that the Tobit model returns when the occurrence of livestock theft estimated in the Probit model (3.7) and the level of livestock theft experienced modelled in the Truncated model (3.8) have the same variables X_i and the same parameter vector β_α (Katchova & Miranda, 2004). Lin & Schmidt (1984) prescribe the Lagrange multiplier to test the restrictions of the Tobit model. Greene (2012) suggests that the restrictions could be tested by calculating the following log-likelihood test statistic (3.9) after the truncated model, the Tobit model and Probit model has been calculated.

$$\lambda = -2\left[\ln L_{Tobit} - \left(\ln L_{Probit} + \ln L_{Truncated\ regression}\right)\right] \tag{3.10}$$

Where:

λ= likelihood ratio statistic

L_{Tobit}= likelihood for the Tobit model

L_{Probit}= likelihood for the Probit model

$L_{Truncated\ regression}$= likelihood for the Truncated model

If the Cragg model has a significant P value (probability) the factors affecting livestock theft will differ significantly from the factors affecting the quantity of livestock theft. If, however, an insignificant P value is found, the variables affecting the occurrence and quantity of livestock theft will be the same and the Tobit model should be efficient for the analysis.

The Cragg test was conducted in NLOGIT 4.0 statistical software.

3.6.2.1 Direction of causality

The Craggs model identified variables which have significant relationships regarding the occurrence as well as the level of livestock theft in the Free State Province. The direction of the causality could however, not be determined from the results. The Granger causality test is also used to determine the direction of causality.

The Granger causality model was developed to determine whether X (livestock theft) is causing Y (control methods) or *vice versa* (Granger, 1969). The idea of Granger causality is to test whether past values of X have explanatory power for current values of Y. It should be noted that even if causality testing proves to be significant, it does not guarantee that X causes Y, therefore the term “Granger causality” is commonly used instead of only “causality” (Koop, 2000). If Granger causality testing indicates that Y is “Granger causing” X, one should be able to better predict X (Granger, 1969).

It is assumed that X and Y are stationary in this study, thus an Autoregressive Distributed Lag (ADL) model will be the appropriate model to use. The ADL model can be expressed as follows (Koop, 2000):

$$Y_t = \alpha + \emptyset_1\ Y_{t-1} + \beta_1 X_{t-1} + e_t \tag{3.11}$$

Where: β_1 = is a measure of the influence of X_{t-1} on Y_t. If β_1 proves to be statistically significant it can be concluded that *X* Granger causes *Y*. However if β_1=0, *X* has no effect on *Y* or alternatively expressed as: past values of *X* have no explanatory power for *Y* beyond that if provided past values for *Y*.

Pair-wise Granger causality tests must be done to identify variables that have an effect on the occurrence of livestock theft as well as the level of livestock theft. The statistical software EViews 7 will be used to conduct the Granger causality testing.

Note that the hypothesised variables were tested for in collinearity. None of the variables proved to have a Variance Inflation Factor above the cut-off value of 10 therefore the variables were individually analysed.

In the next part of the chapter the variables as well as their hypothesised influence on livestock theft are discussed. The internal variables are discussed in the first part followed by the external variables.

3.7 Variables hypothesised to influence livestock theft

The internal and external variables that were considered to influence livestock theft as well as the expected influence of each variable can be seen in Table 3.1 (external) and Table 3.2 (internal). Keep in mind that these variables will be tested to identify variables that significantly influence the occurrence of livestock theft (yes/no) in the Probit model as well as the level of stock theft (how much) in the Truncated model.

3.7.1 Hypothesised external variables

A description and expected influence of each of the external variables are shown in Table 3.1. Remember that the external variables represent the factors that farmers have little or no control over. These external variables were divided into the following sub-categories: Reporting of livestock theft, Demographic variables, Management of farm workers and Topographic variables.

Reporting of livestock theft include: report within 0-1.99 hours, report within 2.00 - 4.99 hours, report within 5.00 – 12.99 hours and report within 13.00 -24.00 hours. Demographic variables include the following: years farming, age of farmer and fulltime farmer. Management of farm workers include the following: average relationship with herdsman, good relationship with herdsman, very good relationship with herdsman, take copy of workers identification document (ID), check new employees' history, pay workers on weekly basis, pay workers on monthly basis, workers go to town every weekend, workers go to town every second weekend, workers go to town once a month, workers receive visitors, visitors walk through farm and number of employees. Topographic variables include the following: plains, mountains, planted pastures, distance from town, distance to informal settlement, size of farm, proximity to big town/city, border and/or stock theft hotspot town.

Table 3.1: The hypothesised external variables that affect livestock theft in the Free State Province and the expected influence of each variable

Variable	**Description**	**Expected influence**
Reporting of livestock theft		
Report within 0-1.99 hours	Dummy variable, coded 1 for reporting theft within 0-1.99 and 0 otherwise.	-/+
Report within 2.00 - 4.99 hours	Dummy variable, coded 1 for reporting theft within 2.00 - 4.99 hours and 0 otherwise.	-/+
Report within 5.00 – 12.99 hours	Dummy variable, coded 1 for reporting theft within 5.00 - 12.99 hours and 0 otherwise.	-/+
Report within 13.00 -24.00 hours	Dummy variable, coded 1 for reporting theft within 13.00 - 24.00 hours and 0 otherwise.	-/+
Demographic variables		
Years farming	Continuous variable.	-/+
Age of farmer	Continuous variable.	-/+
Fulltime farmer[3]	Dummy variable, coded 1 for fulltime farmer and 0 otherwise.	-
Variable	Description	Expected influence
Management of farm workers		
Average relationship with herdsman	Dummy variable, coded 1 for an average relationship with herdsman and 0 otherwise.	-
Good relationship with herdsman	Dummy variable, coded 1 for a good relationship with herdsman and 0 otherwise.	-
Very good relationship with herdsman	Dummy variable, coded 1 for a very good relationship with herdsman and 0 otherwise.	-
Take copy of workers ID	Dummy variable, coded 1 for taking copy of workers ID and 0 otherwise.	-
Check new employees history	Dummy variable, coded 1 or checking new employees' history and 0 otherwise.	-
Pay workers on weekly basis	Dummy variable, coded 1guard and 0 otherwise.	-/+
Pay workers on monthly basis	Dummy variable, coded 1 for paying workers on a monthly basis and 0 otherwise.	-/+

[3]It is assumed that full time farmers are staying on the farm and part time farmers are not staying on the farm.

Variable	Description	Expected influence
Management of farm workers		
Workers go to town every weekend	Dummy variable, coded 1 for workers going to town every weekend and 0 otherwise.	-/+
Workers go to town every second weekend	Dummy variable, coded 1 for workers going to town every second weekend and 0 otherwise.	-/+
Workers go to town once a month	Dummy variable, coded 1 for workers gong to town once a month and 0 otherwise.	-/+
Workers receive visitors	Dummy variable, coded 1 for workers receiving guests on farm and 0 otherwise.	+
Visitors walk through farm	Dummy variable, coded 1 for workers visitors walking through the farm and 0 otherwise.	+
Number of employees	Continuous variable.	+
Topographic variables		
Plains	Dummy variable, coded 1 for plains and 0 otherwise.	-/+
Mountains	Dummy variable, coded 1 for mountains and 0 otherwise.	-/+
Planted pastures	Dummy variable, coded 1 for planted pastures and 0 otherwise.	-/+
Distance from town	Continuous variable	-/+
Distance to informal settlement	Continuous variable	-
Size of farm	Continuous variable	+
Big town/city	Dummy variable, coded 1 for farms close to big cities and 0 otherwise.	-/+
Border	Dummy variable, coded 1 for farms close to the Lesotho border and 0 otherwise.	+
Stock theft hotspot town	Dummy variable, coded 1 for farms close to stock theft hotspot and 0 otherwise.	+

Dummy variables = coded either 0 or 1; Continues variables = can take on any value

As shown in Table 3.1 the hypothesised influence of the different periods it takes to report a stock theft case is uncertain due to the fact that the theft has already taken place. The influence that the age of the farmer and years of farming will have can be hypothesised to be both negative and positive; older farmers might have more knowledge to use when controlling stock theft while younger farmers might still have more motivation to put in extra effort for controlling stock theft. Fulltime farmers are expected to have less stock theft problems due to the fact that the farmer can pay more attention to his farm than a part-time farmer. Better relationships with the herdsman as well as strict control of new employees (taking copies of identification documents and checking employees' criminal history) are hypothesised to be linked to lower stock theft incidences. A larger number of employees are expected to be linked to higher incidences of stock theft based on the findings of Bunei *et al*., (2013). Farms with more mountains are expected to experience more incidences of livestock theft (Barclay & Donnermeyer, 2001). The effect of distance from town is unsure due to authors who have found mixed results (Barclay & Donnermeyer, 2001; Bunei *et al*., 2013). Larger farms are expected to have higher incidences of livestock incidences (Bunei *et al*., 2013). Farms close to the Lesotho border and stock theft hotspot towns are expected to be more affected by stock theft.

3.7.2 Hypothesised internal variables

Internal variables represent the control practices put in place and actions taken by farmers to control livestock theft in the Free State Province. The hypothesised internal variables are tabled in Table 3.2. The internal variables were divided into the following sub-categories: Management practices, Physical barriers, Technologies used, Animals used and Actions taken against stock theft. Management practices include: guards, stock theft informants, strategic use of guards and strategic use of theft informants. Physical barriers include: corral at night, electric fencing, locking gates, strategic corralling, and strategic electric fences. Technologies used include: stock theft collars, cameras, lights in corral, alarm in corral, strategic collars and strategic cameras. Animals used include: guard dogs ostriches, black wildebeest, donkeys, strategic use of dogs. Actions taken against stock theft include: active patrolling, access control, strategic use of patrols, strategic use of access control, count daily, count more than once per day, count once per week, count more than once per week, count monthly, farmers' union patrols, neighbourhood watch patrols, private company patrols.

Table 3.2: The hypothesised internal variables that affect livestock theft in the Free State Province and the expected influence of each

Variable	Description	Expected influence
Management practices		
Guards	Dummy variable, coded 1 for livestock guards and 0 otherwise.	-
Strategic Guard	Dummy variable, coded 1 for strategic use of livestock guards and 0 otherwise.	-
Theft informant	Dummy variable, coded 1 for stock theft informant and 0 otherwise.	-
Strategic Theft informant	Dummy variable, coded 1 for strategic use of livestock theft informant and 0 otherwise.	-

Variable	Description	Expected influence
Physical barriers		
Corral at night	Dummy variable, coded 1for corralling at night and 0 otherwise.	-
Strategic corralling	Dummy variable, coded 1 for strategic corralling and 0 otherwise.	-
Physical barriers		
Lock gates	Dummy variable, coded 1 for locking gates and 0 otherwise.	-
Electric fencing	Dummy variable, coded 1guard and 0 otherwise.	-
Strategic electric fences	Dummy variable, coded 1 for strategic electric fencing and 0 otherwise.	-
Technology used		
Stock theft collar	Dummy variable, coded 1 for stock theft collar and 0 otherwise.	-
Lights in corral	Dummy variable, coded 1 for lights in corral and 0 otherwise.	-
Alarm in corral	Dummy variable, coded 1 for alarm in corrals and 0 otherwise.	-
Camera	Dummy variable, coded 1 for camera and 0 otherwise.	-
Strategic stock theft collar	Dummy variable, coded 1 for strategic collar and 0 otherwise.	-
Strategic camera	Dummy variable, coded 1 for strategic camera and 0 otherwise.	-
Animals used		
Ostriches	Dummy variable, coded 1 for ostrich and 0 otherwise.	-
Donkeys	Dummy variable, coded 1 for donkey and 0 otherwise.	-
Wildebeest	Dummy variable, coded 1 for black wildebeest and 0 otherwise.	-
Dogs	Dummy variable, coded 1 for guard dogs and 0 otherwise.	-
Strategic Dogs	Dummy variable, coded 1 for strategic use of guard dogs and 0 otherwise.	-
Actions taken against stock theft		
Active patrolling	Dummy variable, coded 1 active patrolling and 0 otherwise.	-
Access control	Dummy variable, coded 1for access control and 0 otherwise.	-

Variable	Description	Expected influence
Actions taken against stock theft		
Strategic patrols	Dummy variable, coded 1 for strategic patrols and 0 otherwise.	-
Strategic access control	Dummy variable, coded 1 for strategic use of access control and 0 otherwise.	-
Count daily	Dummy variable, coded 1 for counting daily and 0 otherwise.	-
Count more than once per day	Dummy variable, coded 1 for counting more than once per day and 0 otherwise.	-
Count once per week	Dummy variable, coded 1 for counting more than once per week and 0 otherwise.	+
Count more than once per week	Dummy variable, coded 1 for counting more than once per week and 0 otherwise.	+
Count monthly	Dummy variable, coded 1 for counting monthly and 0 otherwise.	+
Farmers' union patrols	Dummy variable, coded 1 for farmer union patrols and 0 otherwise.	-
Neighbourhood watch patrols	Dummy variable, coded 1 for neighborhood watch patrols and 0 otherwise.	-
Private company patrols	Dummy variable, coded 1 for private company patrols and 0 otherwise.	-

Dummy variables = coded either 0 or 1

Continues variables = can take on any value

A description of the external variable and the expected influence (on the occurrence as well as the level of stock theft) of each variable can be seen in Table 3.2. It is expected that all of the variables under the management practices, physical barriers, technologies used and animals used categories will lower the occurrence of livestock theft. Under actions taken against stock theft it is expected that counting daily, more than once per day is expected to cause lower levels of livestock theft. It is assumed that farmers who count their sheep also keep record. Where patrols and access control are performed it is expected to lower the occurrence of livestock theft.

This chapter is now concluded, the next chapter focuses on the results obtained from the study's data.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter will focus on the results from the analyses and can be divided into three sections. Firstly, the direct cost of livestock theft in the Free State Province will be investigated, followed by an investigation of the indirect cost of losses to stock theft in the Free State Province. Finally the factors affecting the occurrence and level of livestock theft will be discussed. The factors are divided into external and internal variables. The calculations and analyses conducted are based on the data collected in 292 telephonic questionnaires from the five district municipalities in the Free State.

4.2 Descriptive statistics of the data and the Free State Province

Approximately 91% of the total area of the Free State Province is primarily used for agriculture. Grazing land, only suitable for livestock farming (Cattle, sheep and goats), comprises 58% of commercial and 66% of emerging farmland (DAFF, 2013a). The Free State Province stocks approximately 4.8 million sheep which is the third largest number of sheep per province in South Africa; the Eastern Cape Province is the largest (7 million sheep) and the Northern Cape Province is the second largest (6 million sheep). Sheep farming in the Free State was the main focus of this study. Presented in Table 4.1 is a summary of the number of farmers, sheep and farmland in the Free State Province as well as the percentages represented by the study. The total of 292 farmers who were willing to complete their questionnaires represents 4.81% of the 6 065 livestock farmers in the Free State Province (DAFF, 2013a). Of the 4 806 386 sheep and 11 572 000 ha of farm land in the Free State Province it as calculated that this study represents 159 081 sheep (3.31%) and 604 393 ha (5.22%) of land in the province (DAFF, 2014a; DAFF, 2013a.)

Table 4.1: Number of farmers interviewed, hectares of farmland and number of sheep in the Free State Province

	Free State Province	Interviewed	Percentage (%)
Number Farmers	6 065	292	4.81
Number of sheep	4 806 386	159 081	3.31
Farmland (ha)	11 572 000	604 618	5.22

Source: DAFF (2013a); DAFF (2014a); collected data

4.3 Characteristics of respondents and data collected

Illustrated in Table 4.2 is a summary of the respondents' characteristics and data collected. The data indicated that the average age of farmers in the Free State Province is 51 years. This confirms the results of Badenhorst (2014). According to Badenhorst (2014) fewer young people are considering a career in agriculture and are in search of opportunities in other industries.

Table 4.2: Summary of the respondents' characteristics and data collected (n = 292)

Characteristic	Average	Minimum	Maximum	Standard Deviation
Age of respondent (years)	51.16	20	84	13.02
Years farming	24.58	1	68	13.84
Fulltime farmer	86.30%	-	-	-
Number of sheep stolen per farmer	32.45	0	600	63.57
Number of sheep recovered per farmer	5.24	0	222	23.85
Number of employees	7.03	0	45	6.76
Take ID copy	93.5%	-	-	-
Check employees history	87%	-	-	-
Size of farm (ha)	2 070.61	50	12 000	2 111.91
Distance from town (km)	21.26	0	60	10.79
Distance for informal settlement (km)	20.81	0.9	60	10.49

One fact of major concern is that an average of 32 sheep was stolen from each farmer during the three years for which the data was collected (Table 4.2). Many farmers however, did not lose any sheep, with the largest number of sheep stolen per farmer being 600. A great problem is that on average only 5 sheep were retrieved per farmer; thus, on average 27 sheep were lost per farmer.

Years of farming experience proved to have an average of 25 years (Table 4.2). This is understandable with an average age of 51 for farmers. One could argue that on the one hand farmers with more years of farming should have more experience, while on the other hand older farmers might be tired and are not willing to put in extra effort and adapt to the use of new control practices. From the respondents' feedback, 86.30% of the farmers are fulltime farmers.

Statistics on the management of farm workers revealed that on average each farmer employs 7.03 farm workers. Most of the farmers indicated that they do take copies of employees' identification documents (ID) (93.5%) and check new employees' criminal history (87%) at their local police station.

Topographical data collected indicated that the average size of the farming unit is 2 070 ha. The average distance farms are located away from the nearest town is 21 km. Farms are also mostly located 21 km from the nearest informal settlement.

To create an idea of the representativeness of the data throughout the Free State Province, Table 4.3 shows the hectares and sheep represented in the study per district municipality. Note that the percentage of sheep captured per district, as well as the sheep per district as percentage of the total number of sheep in the Free State Province, are shown.

Table 4.3: An overview of the research in the study per district municipality

District municipality	Number of respondents in survey (1)	Ha in the survey (2)	Number of sheep in survey (3)	Number of sheep in the province (4)	Percentage of sheep surveyed per district (%) (5) = (3÷4)	Sheep surveyed as percentage of sheep in Province (%) (6)[4]	Population (7)
Xhariep	45	148 818	67 101	1 960 874	3.42	1.40	146 259
Lejweleputswa	72	140 798	8 941	250 770	3.57	0.19	627 626
Thabo Mofutsanyane	97	180 967	45 039	1 096 944	4.11	0.94	736 238
Fezile Dabi	61	180 967	34 694	1451900	2.39	0.71	488 036
Mangaung	17	31 581	3 306	45 898	7.20	0.07	747 431
Total	292	604 393	159 081	4 806 386		3.31	2 745 590

Source: Statistics South Africa, 2011a; DAFF (2014a) and collected data

The following percentages of sheep are represented per district municipality (Table 4.3): Xhariep 3.42%, Lejweleputswa 3.57%, Thabo Mofutsanyane 4.11%, Fezile Dabi 2.39% and Mangaung 7.20%. When focussing on the sheep represented per district as a percentage of the total number of sheep in the Free State Province it can be seen that the surveyed sheep in the Xhariep district represent the largest (1.40%) portion in terms of the Free State Province. Surveyed sheep in the Thabo Mofutsanyane district represented the second largest percentage (0.94%).

Mangaung district has the highest population density of the five district base on its small size and large population the largest of the five districts (747 431). The second largest population per

[4] Column 6 was calculated by dividing the number of sheep per district by the total number of sheep in the Free State Province.

district is found in the Thabo Mofutsanyane district (736 238). Even though the Xhariep district is relatively large it only houses 146 259 people, the smallest population of the five districts (Statistics South Africa, 2011a). The five large towns identified for the study are located in the following district municipalities: Bloemfontein and Botshabelo in the Manguang district municiplaity, Kroonstad and Sasolburg in the Fezile Dabi district municipality and Welkom located in the Lejweleputswa district municipality.

4.4 The direct cost of livestock theft in the Free State Province

The first sub-objective of this study was to determine the direct cost of sheep theft in the Free State Province. To calculate the direct cost of sheep theft, similar calculations to that of the predation research will be used (Van Niekerk, 2010; Badenhorst, 2014). The market price of an animal will be multiplied by the number of animals lost. Bear in mind that animals lost will be used and not the animals stolen. In some cases animals were retrieved and it would not be accurate to use the number of animals stolen for the calculations.

The annual stock theft rate was calculated by taking the number of animals stolen annually in the survey and dividing it by the number of animals represented in the survey. This value is then expressed as a percentage to reveal the rate at which animals are stolen annually. To calculate the annual loss rate the number of animals stolen annually was taken and the animals retrieved annually was deducted to calculate the number of animals lost annually (not recovered by the police or by the farmers themselves). This number is then divided by the number of animals represented in the survey and expressed as percentage. This annual loss rate indicates the rate at which animals are lost annually. The annual recovery rate expresses the rate at which stolen animals are recovered. It is calculated by dividing the number of animals recovered annually by the number animals stolen annually.

The annual stock theft rate, loss rate and recovery rate calculated from the survey data are shown in Table 4.4. Lejweleputswa district has the highest theft rate (6.78%) and Xhariep district has the lowest theft rate (1.07%). Similar to the theft rate, Lejweleputswa district has the highest loss rate (5.98%) and Xhariep district has the lowest loss rate (0.96%). Note the difference in recovery rates between districts. Manguang has the highest recovery rate (15.83%) and Fezile Dabi district has the lowest recovery rate (4.27%).

One factor that could be influencing the loss rate in the different districts is the size of the population in the area. Xhariep and Fezile Dabi districts have smaller populations than the other districts and also lower loss rates (Statistics South Africa, 2011a). Lejweleputswa district houses one of the identified large towns of the Free State (Welkom) and the districts borders three of the other large towns (Bloemfontein, Kroonstad and Botshabelo). One could, therefore argue that farms closer to urban areas experience higher levels of stock theft (Bunei *et al*., 2013).

Table 4.4: The number of sheep stolen, recovered and lost per District Municipality in the Free State Province

District municipality	Number of sheep surveyed (1)	Number of sheep stolen per year in survey (2)	Number of sheep recovered per year in survey (3)	Number of sheep lost per year in survey (4)	Annual stock theft rate in survey (%) (5) = (2÷1)	Annual loss rate in survey (%) (6) = (4÷1)	Annual recovery rate in survey (%) (7) = (3÷2)
Xhariep	67 101	720	76	644	1.07	0.96	10.56
Lejweleputswa	8 941	606	71	535	6.78	5.98	11.72
Thabo Mofutsanyane	45 039	1 104	65	1 039	2.45	2.31	5.89
Fezile Dabi	34 694	609	26	583	1.76	1.68	4.27
Mangaung	3 306	120	19	101	3.63	3.06	15.83
Total	159 081	3 159	257	2 902	1.99	1.82	8.14

The annual loss rate calculated in Table 4.4 was used to calculate the direct cost of livestock theft in the Free State Province. The number of sheep used is an estimate provided by the Department of Agriculture, Fisheries and Forestry for commercial farmers only (DAFF, 2014a). A monetary value of R1 700 per animal (sheep) was used as the market value of the animals. This value per animal was determined by the National Stock Theft Forum of the Red Meat Producers Organization in 2012 (RPO, 2012b). This market value of animals will serve as a base and can be changed for future calculations (Badenhorst, 2014).

The direct costs of sheep theft in the Free State Province of South Africa are shown in Table 4.5. If assumed that the data captured in the survey is accurate, the annual direct financial impact of sheep theft in Free State Province is estimated at approximately R144 million. Based on the data it estimated that 84 955 sheep are annually lost to stock theft in the Free State Province (Table 4.5). Thabo Mofutsanyane district experienced the largest direct annual loss (R43 076 300) to livestock theft of all the districts and Manguang had the smallest annual financial loss (R2 386 800). Even though Lejweleputswa had the highest loss rate, the small number of sheep in the district led to low direct annual losses.

Table 4.5: The direct cost of livestock theft in the Free State Province per district

District municipality	Annual loss rate in survey (%) (1)	Number of sheep within the province (2)	Total number of sheep lost annually according to survey (3) = (1x2)	Annual direct costs according to survey (R) (4) = (3x R1700)
Xhariep	0.96	1 960 874	18 824	32 000 800
Lejweleputswa	5.98	250 770	14 996	25 493 200
Thabo Mofutsanyane	2.31	1 096 944	25 339	43 076 300
Fezile Dabi	1.68	1 451 900	24 392	41 466 400
Mangaung	3.06	45 898	1 404	2 386 800
Total for province	-	4 806 386	84 955	144 423 500

Source: DAFF (2014a) and collected data

When comparing the result of the study to the official statistics from the National Stock Theft Prevention Forum for the same period that the data was collected (Table 4.6), it can be seen that there is a big difference in theft rates, loss rates as well as the recovery rates. According to the data from the study the theft rate is close to 1.99% and loss rate approximately 1.82% (Table 4.4). Official statistics show a far lower stock theft rate (0.54%) and loss rate (0.41%). The data suggests that the number of sheep lost annually is 84 955 while the official statistics show losses of 19 772. This means that according to the data, livestock theft is not correctly expressed in the official statistics and that the true impact of livestock theft is hugely underestimated and agrees with the findings of Scholtz & Bester (2010).

Table 4.6: Livestock theft statistics of the study compared to official numbers

	Total number of sheep stolen annually (1)	Number of sheep recovered annually (2)	Number of sheep lost annually (3)	Annual theft rate (%)	Annual loss rate (%)	Annual recovery rate (%)
In the study	92 077[5]	7 148[6]	84 955[7]	1.99[8]	1.82[9]	8.14[10]
Official data	26 193	6 421	19 772	0.54	0.41	24.26

Source: NSTPF (2014) and own calculations

[5] As calculated in Table 4.4
[6] As calculated in Table 4.4
[7] As calculated in Table 4.4
[8] As calculated in Table 4.4
[9] As calculated in Table 4.4
[10] As calculated in Table 4.4

An explanation for this result could be the fact that not all victims are reporting livestock theft incidences, with the non-reporting rate in 2013/14 at 64.4% (Statistics South Africa, 2014a). Some reasons why farmers do not report cases were identified during the research. Farmers indicated they do not feel that it would help, in some cases the police arrive much later than the case was reported and the chances of recovering the stolen animals are slim. Some farmers realise the theft at a stage too late to act on it and others indicated that they only report thefts of larger numbers and not one or two at a time. On one occasion the farmer indicated that the police themselves are involved in the thefts. These reasons are similar to many of the reasons given in Statistics South Africa (2014a) for farmers who do not report.

4.5 The indirect cost of livestock theft in the Free State Province

The second sub-objective of this study was to determine the indirect cost for livestock theft in the Free State Province. The indirect cost represents the expenditure associated with practices used for controlling livestock theft. Practices used for controlling livestock theft (internal variables) can be further divided into methods used and actions taken to control livestock theft.

The methods used will include the management practices, physical barriers, technology and animals used to control livestock theft. Actions taken include the actions taken by the farmer himself to control livestock theft; patrols, access control and other management aspects. Keep in mind that in some cases farmers only use control methods/actions during problematic times of the year (e.g. Christmas and Easter weekends) which tend to have a higher livestock theft occurrence. In these cases methods/actions were specified as “strategic” methods or actions.

4.5.1 Methods used to control livestock theft in the Free State

Methods used to control livestock theft in the Free State Province where identified during telephonic interviews and the results are shown in Table 4.7. The use of control methods differs slightly between districts with corralling of sheep (actively and strategically) being the most popular method in all districts. In the Lejweleputswa district 75% of the farmers are corralling their sheep (actively and strategically) at night while in the Fezile Dabi district less than 28% of the farmers are corralling (actively and strategically) their sheep at night.

Besides corralling animals at night the Xhariep district indicated that dogs (active and strategic) is their preferred control method (24.44%). This was also the case in Lejweleputswa district where approximately 21% of farmers are using dogs as control method (active and strategic). In the Thabo Mofutsanyane district the second highest used method is guards (actively and strategically) at 14.43%. Stock theft collars (actively and strategically) proved to be the second highest used control method in the Fezile Dabi district (18.03%). In the Mangaung district two methods came in second place, guards (11.76%) and lights in corral (11.76%).

Taking into account the Free State Province, the leading method that farmers are using to control livestock theft is corralling animals at night. More than 33% of the farmers are actively corralling their sheep at night. Approximately 14% of farmers are corralling their sheep during known problematic times of the year. Surprisingly though, one farmer specifically indicated that he has experienced more livestock theft since he started corralling his animals because it is easier to catch them in a confined area. The use of a guard is the second highest used method at 10% actively and 3% strategically. When combining the use of dogs (actively and strategically) we see that more than 13.6% of the farmers are using guard dogs. It is interesting to note that respectively approximately 10% of the farmers are using stock theft collars (active and strategic), 8.2% are using cameras either actively or strategically and 3.4% of the farmers are using alarms. It seems that technological innovation is taking place in farming, specifically in the livestock industry that strives to solve problems with new technological answers.

Table 4.7: Methods used to control livestock theft

	Xhariep (%)	Lejweleputswa (%)	Thabo Mofutsanyane (%)	Fezile Dabi (%)	Mangaung (%)	Free State Province (%)
Management practices						
Guards	11.11	11.11	10.31	8.20	11.76	10.27
Strategic Guard	2.22	2.78	4.12	1.64	0.00	2.74
Theft informant	2.22	0.00	3.09	1.64	0.00	1.71
Strategic Theft informant	2.22	4.17	7.22	6.56	0.00	5.14
Physical barriers						
Corral at night	17.78	51.39	35.05	21.31	29.41	33.22
Strategic Corralling	11.11	23.61	11.34	6.56	23.53	14.04
Lock gates	0.00	0.00	3.09	0.00	0.00	1.03

	Xhariep (%)	Lejweleputswa (%)	Thabo Mofutsanyane (%)	Fezile Dabi (%)	Mangaung (%)	Free State Province (%)
Physical barriers						
Electric fencing	0.00	6.94	5.15	3.28	0.00	4.11
Strategic Electric fences	2.22	2.78	0.00	0.00	0.00	1.03
Technology used						
Lights in corral	0.00	0.00	2.06	0.00	11.76	1.37
Alarm in corral	2.22	4.17	5.15	0.00	5.88	3.42
Camera	11.11	9.72	3.09	1.64	5.88	5.82
Strategic Camera	4.44	2.78	2.06	1.64	0.00	2.40
Stock theft collar	6.67	6.94	4.12	13.11	5.88	7.19
Strategic Stock theft collar	2.22	2.78	3.09	4.92	0.00	3.08
Animals used						
Ostrich	6.67	1.39	1.03	0.00	0.00	1.71
Donkey	2.22	5.56	5.15	4.92	0.00	4.45
Wildebeest	2.22	0.00	1.03	0.00	0.00	0.68

	Xhariep (%)	Lejweleputswa (%)	Thabo Mofutsanyane (%)	Fezile Dabi (%)	Mangaung (%)	Free State Province (%)
Animals used						
Dogs	11.11	16.67	10.31	0.00	0.00	9.25
Strategic Dogs	13.33	4.17	3.09	1.64	0.00	4.45

The financial implications of methods used to control livestock theft in the Free State Province are shown in Table 4.8. The annual total costs for control methods used per district were added to determine the total cost of control methods for the Free State Province.

Table 4.8: Cost of methods used to control livestock theft in the Free State Province

District municipality	Total annual cost of control methods in the survey (R) (1)	Number of sheep in survey (2)	Total annual cost of control methods per sheep in survey (R) (3) = (1÷2)	Number of sheep within the province (4)	Total annual cost of control methods according to survey (R) (5) = (3x4)
Xhariep	90 954	67 101	1.36	1 960 874	2 666 789
Lejweleputswa	257 850	8 941	28.84	250 770	7 232 207
Thabo Mofutsanyane	315 340	45 039	7.00	1 096 944	7 678 608
Fezile Dabi	123 980	34 695	3.57	1 451 900	5 183 283
Mangaung	40 972	3 306	12.39	45 898	568 676
Total	829 095	159 082	-	4 806 386	23 329 563

It is hypothesised that the data used for the calculations is representative of the Free State Province. Based on this assumption the total annual cost of methods used to control livestock theft in the Free State Province was calculated at R23 329 563 (Table 4.8). The Thabo Mofutsanyane district spent the largest amount (R7 678 608) of money on livestock theft control methods annually of all the district municipalities, with Lejweleputswa district spending the second highest amount (R7 232 207). The Mangaung district spent the smallest amount of money (R568 676) on control methods annually; however, this amount is the result of the lower number of sheep in the district and not a smaller amount per animal. In fact, the Mangaung district has the second highest amount spent on control methods per animal (R12.39) second to Lejweleputswa district. It should be noted how high the annual cost of control methods are per sheep (R28.84) in the Lejweleputswa district compared to the other districts. The annual cost of control methods in Lejweleputswa is more than twice (R28.84) as high as that of the Mangaung district (R12.39). Based on the data, the Xhariep district annually spends the lowest amount (R1.36) on control methods per sheep of all the districts.

4.5.2 Actions taken to control livestock theft in the Free State Province

The actions taken by farmers to control livestock theft in the Free State Province are shown in Table 4.9. In all of the districts patrols are preferred to access control. In four of the five districts the largest portion of the farmers are counting their livestock on a daily basis; however, in the Xhariep district the largest portion of the farmers indicated that they count once per week.

Patrols seem to be preferred above access control in the Free State Province with almost 48% of the farmers actively patrolling. More than 15% of farmers are only patrolling during problematic times of the year. Approximately 20% of the farmers put in place access control on an active basis and a further 13% are strategically using access control. What is gratifying, is that almost 52% of the farmers are counting their animals on a daily basis, with 3% of these farmers counting more than once per day. Approximately 20% of the farmers are not counting of a daily basis but more than once a week; approximately 34% of the farmers are counting their animals on a weekly basis and a disturbing fact is that approximately 4% of the farmers are only counting once a month. When looking at the counting of animals it seems that most of the farmers are willing to put in extra effort to control livestock theft and ensure early detection of stolen animals. However, there are still individuals that might detect that animals are stolen at a stage too late to act. It should be taken into account that it is not always possible for a farmer to count his animals on a daily basis because of the time requirement of other farm enterprises. For example, during the planting season of maize, farmers have little time to attend to livestock requirements. It is also possible that the livestock are not being kept in an isolated area and can only be counted on a weekly basis.

Table 4.9: Actions taken to control livestock theft

	Xhariep (%)	Lejweleputswa (%)	Thabo Mofutsanyane (%)	Fezile Dabi (%)	Mangaung (%)	Free State Province (%)
Actions taken against stock theft						
Active patrols	60.00	38.89	52.58	39.34	58.82	47.95
Access control	31.11	9.72	23.71	16.39	23.53	19.86

	Xhariep (%)	Lejweleputswa (%)	Thabo Mofutsanyane (%)	Fezile Dabi (%)	Mangaung (%)	Free State Province (%)
Actions taken against stock theft						
Strategic Patrols	6.67	19.44	10.31	29.51	0.00	15.41
Strategic access control	15.56	11.11	11.34	19.67	0.00	13.01
Count daily	24.44	58.33	54.64	42.62	70.59	49.32
Count more than once per day	2.22	1.39	3.09	3.28	0.00	2.40
Count once per week	40.00	33.33	37.11	31.15	17.65	34.25
Count more than once per week	31.11	13.89	15.46	26.23	17.65	19.86
Count monthly	8.89	5.56	2.06	1.64	5.88	4.11

The annual financial implications of actions taken to control livestock theft in the Free State Province were calculated on a similar basis to that of control methods and are shown in Table 4.10. The total annual costs for control actions taken per district were added to determine the total cost of control actions for the Free State Province.

Table 4.10: Cost of actions taken to control livestock theft in the Free State Province

District municipality	Total annual cost of actions in the survey (R) (1)	Number of sheep in survey (2)	Total annual cost of actions per sheep in survey (R) (3) = (1÷2)	Number of sheep within the province (Table 4.5) (4)	Total annual cost of control actions according to survey (R) (5) = (3x4)
Xhariep	164 535	67 101	2.45	1 960 874	4 804 141
Lejweleputswa	43 959	8 941	4.92	250 770	1 233 788
Thabo Mofutsanyane	148 675	45 039	3.30	1 096 944	3 619 915
Fezile Dabi	128 766	34 695	3.71	1 451 900	5 386 549
Mangaung	11 747	3 306	3.55	45 898	162 938
Total	497 681	159 082	-	4 806 386	15 207 331

According to the data the total annual cost of actions taken to control livestock theft in the Free State Province (Table 4.10) was estimated at R15 207 331. This is lower than the amount spent annually on control methods. Contrary to the control methods, we see that the total costs of actions per sheep are much closer to each other between districts. Based on the data, the Xhariep district spent the smallest amount annually per sheep (R2.45) on actions taken and Lejweleputswa district the largest amount per sheep annually (R4.92). In total, Fezile Dabi district spent the largest amount of capital (R5 386 549) on control actions annually and Mangaung district the smallest amount (R162 938). It is interesting to see the difference in spending trends between the farmers in the districts. Fezile Dabi farmers spent almost equal amounts on control methods (R3.57) and actions (R3.71), whereas farmers in the Lejweleputswa district spent almost five times more on methods (R28.84) than they did on control actions (R4.92).

The relatively small difference in cost of actions between districts could be an indication that farmers are applying more or less the same level of control actions. Whereas the relatively large difference in the cost of methods per sheep between the districts, indicates that farmers in some of the districts are investing far more money into methods in an attempt to control livestock theft. Earlier in the chapter it was determined that Lejweleputswa district had the highest annual stock theft rate (6.78%). This large amount spent per sheep on control methods could thus be the result of attempts to lower the high stock theft rate.

4.6 Total cost of livestock theft in the Free State Province

The main objective of this study is to determine the financial impact of sheep theft in the Free State Province of South Africa. The total annual cost of livestock theft in the Free State Province includes the cost of methods, cost of actions and direct cost of losses (Table 4.11).

Based on the data the Thabo Mofutsanyane district experienced the largest impact from livestock theft (R54 374 823) of all the districts and Fezile Dabi district had the second largest losses to livestock theft (R52 036 232). The Mangaung district had the smallest financial implication (R3 118 414). The total annual cost of livestock theft in the Free State Province is estimated at R182 960 394. This result shows that the cost of sheep theft is less than that of annual sheep predation (R237 205 338) in the Free State Province (Van Niekerk, 2010), but the financial losses both for livestock theft and predation are still significantly high.

Table 4.11: Total direct and indirect cost of livestock theft in the Free State Province

District municipality	Total annual cost of methods used according to survey (R) (Table 4.8) (1)	Total annual cost of actions taken according to survey (R) (Table 4.10) (2)	Annual direct costs of livestock theft according to survey (R) (Table 4.5) (3)	Total annual cost according to survey (R) (4) = (1+2+3)
Xhariep	2 666 789	4 804 141	32 000 800	39 471 730
Lejweleputswa	7 232 207	1 233 788	25 493 200	33 959 195
Thabo Mofutsanyane	7 678 608	3 619 915	43 076 300	54 374 823
Fezile Dabi	5 183 283	5 386 549	41 466 400	52 036 232
Mangaung	568 676	162 938	2 386 800	3 118 414
Total	23 329 563	15 207 331	144 423 500	182 960 394

4.7 External variables that affect livestock theft

Results for the external variables hypothesised to affect the occurrence and level of livestock theft in the Free State Province consist out of Tobit (level), Probit (occurrence) and Truncated (level) results which are shown in Table 4.12. The Craggs test was used to determine whether the variable affecting the occurrence of livestock theft are significantly different from the variables affecting the level of livestock theft experienced. If the variables prove to affect both the occurrence and level of stock theft experienced the Tobit model will be the model of choice. However, if the variables affecting the occurrence of stock theft prove to be different form the variables affecting the level, the Tobit and Truncated model must be used.

The aim of these regressions is not to predict the probability of livestock theft but rather identify the internal and external variables associated with a lower probability of livestock theft. Thus, a significance level of 15% was used as cut-off value for significant variables. In order to ease discussion and identify trends, external variables were divided into suitable categories namely: reporting of livestock theft, management of farm workers, demographic variables and topographic variables.

Table 4.12: Regression results of the Tobit, Probit and Truncated specifications when analysing external variables affecting livestock theft

Variable	**Tobit**	**Probit**	**Truncated**
Dependent variable	**Number of sheep stolen**	**Dummy = 1 if experienced theft, otherwise 0**	**Number of sheep stolen**
Constant	-173.4253****	-3.2335****	85.2656
	(56.3445)	(0.8090)	(269.6226)
Reporting of livestock theft			
Report within 0-1.99 hours	108.4810****	1.7436****	-17.8845
	(18.5546)	(0.2446)	(88.3507)
Report within 2.00- 4.99 hours	135.0665****	1.7156****	104.1057
	(24.3078)	(0.3389)	(101.9826)
Report within 5.00 – 12.99 hours	113.0441****	2.1386****	-66.6959
	(34.5546)	(0.5952)	(135.7859)
Report within 13.00-24.00 hours	110.4856****	0.9739**	226.0078**
	(38.5791)	(0.5293)	(131.2323)
	Tobit	**Probit**	**Truncated**
Management of farm workers			
Average relationship with herdsman	38.8593	0.2611	54.8602
	(32.9979)	(0.5011)	(122.4384)
Good relationship with herdsman	41.2272	0.5193	27.1038
	(28.7994)	(0.4468)	(113.2347)
Very good relationship with herdsman	16.5898	0.2078	-36.9059
	(28.8577)	(0.4435)	(115.4441)
Take ID copy	32.0676	0.0026	119.3469
	(32.3090)	(0.5289)	(100.5505)
Check employees' history	-17.0609	-0.0676	-123.6627**
	(21.3817)	(0.3485)	(63.6703)
Pay workers on weekly basis	-29.3835	-0.3287	-35.0568
	(50.0152)	(0.7251)	(218.5194)

	Tobit	Probit	Truncated
Management of farm workers			
Pay workers on monthly basis	36.9110	0.9789*	51.6999
	(44.9871)	(0.6690)	(221.97320
Workers go to town every weekend	3.5809	0.0426	-10.5054
	(27.6891)	(0.4206)	(102.6302)
Workers go to town every second weekend	-37.9533	-0.3076	-264.2264**
	(31.1944)	(0.4720)	(143.3688)
Workers go to town once a month	-30.4430	-0.3608	-99.3744
	(25.7465)	(0.3913)	(96.5304)
Workers receive visitors	24.9691	0.1464	91.0263
	(24.4536)	(90.3518)	(97.9315)
Visitors walk through farm	-0.3027	0.1936	-45.3874
	(14.0565)	(90.2237)	(47.7825)
Number of employees	-0.3118	-0.0126)	0.8742
	(1.0411)	(90.0157)	(3.7305)
Demographic variables			
Years farming	0.2528	0.0028	1.0222
	(0.4992)	(0.0077)	(1.7542)
Age	-0.1515	0.0017	-1.0781
	(0.5561)	(0.0083)	(2.1080)
Fulltime farmer	-15.7624	0.0501	-105.1946*
	(19.3036)	(0.2932)	(67.2876)
Topographic variables			
Plains	15.4593	0.8169****	-176.8991***
	(19.2827)	(0.2909)	(72.4865)
Mountains	16.1734	0.0192	73.6144
	(16.3314)	(0.2667)	(56.3414)

	Tobit	Probit	Truncated
Topographic variables			
Planted pastures	-8.6230	-0.2158	25.0973
	(12.4697)	(0.1932)	(45.4221)
Distance from town	1.3980	0.0392**	-4.2555
	(1.4501)	(0.0211)	(4.7594)
Distance to informal settlement	-1.1857	-0.0279	2.4076
	(1.4783)	(0.0217)	(4.7692)
Size of farm	0.0070***	0.0052	0.0195***
	(0.0031)	(0.0049)	(0.0097)
Large town	-7.8256	-0.2227	29.8487
	(17.4066)	(0.2533)	(63.8693)
Border	45.3178**	1.4644****	27.4206
	(24.9301)	(0.5467)	(80.6962)
Stock theft hotspot	9.1803	0.1651	28.8618
	(20.0244)	(0.3010)	(73.5946)
	Tobit	**Probit**	**Truncated**
GOODNESS OF FIT			
No. of observations	292	292	292
Sigma	84.0267****		113.0711****
	(4.8356)		(12.0814)
Log likelihood	-1034.1803	-199.6506	-830.5208
% Correct prediction		77.055%	
McFadden R^{2a}		0.2933	
Model chi-square [b]		117.0961	
Significance level [c]		(0.0000)	
LR test for TOBIT vs truncated regression			125.1138[d]
			(0.0000)[c]

Note:
**** = statistical significance of 1%
*** = statistical significance of 5%
** = statistical significance of 10%

* = statistical significance of 15%
Standard errors are in parentheses.
[a] McFadden R^2 is given by one minus the ratio of the unrestricted to restricted log likelihood function values.
[b] The chi-square test evaluates the null hypothesis that all coefficients (not including the constant) are jointly zero.
[c] Numbers in parentheses are associated with chi-square probabilities
[d] The likelihood ratio test is given by $\lambda=2\ (\ln L_{Probit} + \ln L_{Truncated\ regression} - \ln L_{Tobit})$.

The Graggs test indicated whether the variables affecting the occurrence of livestock theft are significantly different from the variables affecting the level of livestock. Results from the Graggs test (Table 4.12) indicate that the log-likelihood test ratio of 125.11 is highly significant (p<0.01). Therefore, the Tobit specifications are rejected in favour of the more general Graggs model specification. Thus, external variables affecting the occurrence of livestock theft are significantly different from the variables affecting the level of livestock theft in the Free State Province.

The Probit regression (Table 4.12) identified eight external variables that have a significant relationship with the occurrence of livestock theft in the Free State Province. The reporting of livestock theft shows that all of the reporting options offered to farmers proved to be significant: REPORT WITHIN 0-1.99 HOURS (p<0.01), REPORT WITHIN 2.00 - 4.99 HOURS (p<0.01), REPORT WITHIN 5.00 – 12.99 HOURS (p<0.01), REPORT WITHIN 13.00 -24.00 HOURS (p<0.10). Strangely, all of these variables proved to be positively related to the occurrence of livestock theft. Thus, it does not matter how long it took to report the theft, the probability of the occurrence of livestock theft increases. Under the management of the farm workers variables, PAYING WORKERS ON A MONTHLY BASIS (p<0.15) showed a positive relationship to the occurrence of livestock theft. This implies that where farm workers were paid once a month there was a higher probability for the occurrence of livestock theft. Results for the topographic variables showed that PLAINS (p<0.01), DISTANCE FROM TOWN (p<0.10) and BORDER (p<0.01) all related with the occurrence of livestock theft in a positive direction. Thus, farms with more plains (flatter land) are more likely to experience livestock theft. This contradicts the findings of Barclay & Donnermeyer, (2001) who found that higher stock theft rates are experienced in hilly terrain. It should also be taken into account that large parts of the Free State Province are relatively flat. Farms further away from towns have a higher probability for the occurrence of livestock theft; this agrees with the findings of Barclay & Donnermeyer, (2001) but contradict the findings of Bunei *et al*., (2013). One could argue that isolated farms create the opportunity for theft without being seen by the farmer. Lastly, farms close to the Lesotho border are more likely to experience livestock theft.

The external variables that have a significant relationship with the level of livestock theft experienced in the Free State Province are shown by the Truncated results in Table 4.12. Contrary to the result from the Probit model, only the REPORTING THEFT WITHIN 13.00-24.00 HOURS (p<0.10) variable proved to be significant in the reporting of livestock theft category. Thus, farmers who experienced a higher level of stock theft tended to report a crime 13.00 –

24.00 hours after it was committed. Management of farm workers had two significant variables: CHECKING EMPLOYEES' HISTORY ($p<0.10$) and WORKERS GO TO TOWN EVERY SECOND WEEKEND ($p<0.10$). Both of these variables had a negative sign for their coefficient. The results thus suggest that checking employees' history and taking workers to town every second weekend are associated with lower levels of livestock theft. One reason why checking employees' history was associated with lower levels of livestock theft could be that no farmer would hire a known criminal. In cases where workers are taken to town every second weekend it could ensure that they are able to buy enough food in town so that they do not need to steal livestock for food, if that was the case. It could also be a sign that farm workers are involved in organised crime and could be serving as informants to criminals when not taken to town however this result should not be generalized for all farmworkers.

Demographic variables indicated that FULLTIME FARMERS ($p<0.15$) experience a lower level of stock theft. This could be due to the fact that fulltime farmers usually have more time to check up on the livestock and can detect any strange activity on the farm during the day. Topographic factors that proved to be significant with the level of stock theft experienced was PLAINS ($p<0.05$) and SIZE OF THE FARM ($p<0.05$). When interpreting the direction of signs, plains had a negative sign meaning farms which have more plains (flatter) experience a lower level of livestock theft. It could be that a thieve will not easily be able to hide a large number of animals in a flat area but it could easily be done in mountainous terrain. The size of the farm had a positive relationship, which means that farmers who have larger farms have experienced higher levels of livestock theft. This is simply because a farmer will struggle to focus on the whole farm simultaneously. Paddocks far from the farm house might also not be in line of sight to detect any strange activity immediately.

Results show that farmers who report their incidents of crime in any of the offered time slots increase their probability of experiencing livestock theft. However, farmers who have a higher probability of experiencing stock theft and a higher level of stock theft report their cases 13.00 – 24.00 hours after the animals are stolen. The results thus suggest that farmers who took longer to report their cases were more likely to experience stock theft and farmers who experienced stock theft at higher level on a regular basis took longer to report. It could be that those farmers who lost large numbers of animals on a regular basis are fed-up with the thefts and probably feel that it would not help to report the cases as early as possible. Interesting to note is that plains proved to be significantly related to a higher occurrence rate of livestock theft and negatively to the level of livestock theft experienced. The results suggest that it is easier to steal one or two sheep in a flat environment; however, it is hard to conceal a large number of sheep at a time. Thus, thefts occur on a regular basis in small quantities on flatter land, whereas more mountainous areas create the opportunity to steal a larger number of animals on a less frequent basis. Strangely it seems that farms bordering Lesotho experience stock theft on a more regular basis, but not necessarily on a larger scale than the rest of the Free State Province.

4.8 Internal variables affecting the occurrence of livestock theft

The internal variables hypothesised to affect the occurrence and level of livestock theft in the Free State Province were analysed and the results are shown in Table 4.13. In order to ease discussion and help identify trends, external variables were also divided into groups, namely: management practices, physical barriers, technology used, animals used and actions taken against stock theft.

Table 4.13: Regression results for the Tobit, Probit and Truncated specifications when analysing internal variables influencing livestock theft

Variable	**Tobit**	**Probit**	**Truncated**
Dependent variable	**Number of sheep stolen**	**Dummy = 1 if Experienced theft, otherwise 0**	**Number of sheep stolen**
Constant	-65.1119****	-0.6914**	-210.2690**
	(25.0723)	(0.3668)	(111.7880)
Management practices			
Guards	34.5417**	0.4824*	25.6400
	(17.8570)	(0.2983)	(54.5760)
Strategic Guard	-15.3475	0.2301	-200.0290
	(32.9571)	(0.5915)	(161.2492)
Theft informant	167.7423****	1.0776	340.2137****
	(39.2791)	(0.7645)	(86.7694)
Strategic Theft informant	29.0855	0.3976	129.3073**
	(24.5194)	(0.4269)	(75.0451)
Physical barriers			
Corral at night	42.6286****	0.9725****	-34.0825
	(12.9723)	(0.2045)	(48.4926)
Strategic Corralling	26.4890*	0.1120	168.5605****
	(17.4323)	(0.2827)	(64.3844)
Lock gates	32.8182	0.6940	-210.6150
	(54.71061)	(0.8656)	(378.8318)
Electric fencing	-0.6457	-0.2567	140.8787
	(30.5192)	(0.4543)	(107.4632)
Strategic Electric fences	-73.6186	-1.1324	-37.4893
	(58.3410)	(0.7962)	(331.9862)

Variable	Tobit	Probit	Truncated
Technology used			
Stock theft collars	55.6696****	0.9733****	128.1724***
	(20.1175)	(0.3713)	(63.1425)
Lights in corral	-59.0573	-1.2619*	172.9464
	(58.8714)	(0.8661)	(271.1620)
Alarm in corral	24.4059	1.2170***	-134.6190
	(30.1628)	(0.5705)	(120.4728)
Camera	80.7218****	0.1899	236.6964****
	(23.0408)	(0.3820)	(66.2950)
Strategic Stock theft collars	50.8349**	1.2312***	1.1539
	(30.4859)	(0.6117)	(86.6459)
Strategic Camera	37.8077	0.6102	-45.2779
	(35.2207)	(0.6110)	(109.6997)
Animals used			
Ostrich	35.9263	0.4373	156.4953
	(44.8285)	(0.6499)	(134.5210)
Donkey	-4.3010	0.0990	-136.4890
	(27.6415)	(0.4161)	(121.2614)
Wildebeest	-41.6752	0.1438	-69.1198
	(83.2292)	(1.1605)	(236.7963)
Dogs	8.1136	0.0788	50.9674
	(22.5095)	(0.3612)	(89.4025)
Strategic Dogs	-15.2595	0.3690	-123.5780
	(30.0255)	(0.5280)	(111.2376)
Actions taken against stock theft			
Active patrols	32.9270***	0.1381	156.1180****
	(13.5464)	(0.2002)	(57.9760)
Access control	-1.4453	0.2898	-108.1990*
	(15.3461)	(0.2303)	(67.5339)

Variable	Tobit	Probit	Truncated
Actions taken against stock theft			
Strategic Patrols	14.2459	0.2953	5.5086
	(18.1697)	(0.2869)	(64.7334)
Strategic access control	29.9737**	0.0083	103.5554**
	(17.7402)	(0.2829)	(54.7067)
Count daily	-18.1366	-0.3721*	-35.1218
	(15.0682)	(0.2302)	(53.3414)
Count more than once per day	-34.7825	-0.6842	-40.3194
	(42.0292)	(0.5651)	(215.4136)
Count once per week	-0.7589	0.0944	-78.5614
	(15.0015)	(0.2269)	(57.0154)
Count more than once per week	24.0160	0.5281***	-9.9554
	(17.2187)	(0.2691)	(57.2689)
Count monthly	23.7764	0.5931	-34.7871
	(30.1053)	(0.5154)	(108.8222)
Farmers union patrols	13.1396	0.1899	14.5626
	(17.6982)	(0.2662)	(66.8547)
Neighbourhood watch patrols	-8.0858	0.2093	-116.6720*
	(17.5835)	(0.2781)	(71.2700)
Private company patrols	20.5376	0.1392	48.3712
	(19.6144)	(0.2961)	(68.7394)
No Patrols	14.4166	0.1087	12.5930
	(22.0436)	(0.3254)	(85.0541)

	Tobit	Probit	Truncated
GOODNESS OF FIT			
No. of observations	292	292	292
Sigma	81.1383****		106.2761****
	(4.6923)		(12.4284)
Log likelihood	-1046.2581	-163.0667	-815.9966
% Correct predictions		69.63%	
McFadden R^{2a}		0.1855	
Model chi-square [b]		74.2947	
Significance level [c]		(0.0000)	
LR test for TOBIT vs truncated regression			134.3896[d]
			(0.0000)[c]

Note:
**** =statistical significance of 1%
*** =statistical significance of 5%
** =statistical significance of 10%
* =statistical significance of 15%
Standard errors are in parentheses.
[a] McFadden R^2 is given by one minus the ratio of the unrestricted to restricted log likelihood function values.
[b] The chi-square test evaluates the null hypothesis that all coefficients (not including the constant) are jointly zero.
[c] Numbers in parentheses are associated with chi-square probabilities
[d] The likelihood ratio test is given by $\lambda=2$ (ln L_{Probit} + ln $_{LTruncated\ regression}$ – ln L_{Tobit}).

Similar to the findings for the external variables (Table 4.12), results from the internal variables (Table 4.13) indicate that the log-likelihood test ratio of 134.39 is highly significant ($p<0.01$). Therefore, the Tobit specifications are relaxed in favour of the more general Graggs model. Thus, internal variables affecting the occurrence of livestock theft are significantly different from the variables affecting the level of livestock theft. If the Tobit model were to be used it would fail to identify the correct variables affecting livestock theft.

Eight of the internal variables have a significant relationship with the occurrence (Probit) of livestock theft in the Free State Province. The use of livestock GUARDS ($p<0.15$) proved to be the only significant management variable positively related to the occurrence of stock theft. Thus, farmers who have a higher probability of experiencing livestock theft are making use of guards. Thus, farmers who experienced livestock theft on a regular basis have started to use guards, in an attempt to control livestock theft. The only significant physical barrier variable affecting the occurrence of livestock theft is CORRALLING AT NIGHT ($p<0.01$). The positive sign of the coefficient would imply that farmers who have a higher probability of experiencing livestock theft are corralling at night. This could be similar to the use of guards where the sheep are corralled in an attempt to control livestock theft. Three of the technology variables proved to be positively related to the occurrence of livestock theft and only one negatively. STOCK THEFT COLLARS ($p<0.01$), ALARMS IN CORRAL ($p<0.05$) and STRATEGIC STOCK THEFT COLLARS ($p<0.05$) positively related, while LIGHT IN CORRAL ($p<0.15$) was negatively related to the occurrence of livestock theft. The results suggest that farmers who are more likely to experience livestock theft used stock theft collars. It does not matter whether the stock theft collars are used actively or strategically. Farmers who are more likely to experience livestock theft placed alarms in their corrals and farmers who have light in their corrals are less likely to experience livestock theft. It seems that farmers are using stock theft collars and alarms because of regular losses to stock theft and that where lights are placed in corrals it has led to lower occurrence rates of livestock theft.

None of the animals used to control livestock theft proved to have a significant relationship with the occurrence of livestock heft. Although it was hypothesised that many of the actions taken by farmers could influence the occurrence of livestock theft, only two proved to be significant. COUNTING ANIMALS ON A DAILY BASIS ($p<0.15$) was negatively related to the occurrence of livestock theft and COUNTING ANIMALS MORE THAN ONCE PER WEEK ($p<0.05$) had a positive relationship to the occurrence of livestock theft. Thus, farmers who count their animals on a daily basis are less likely to experience livestock theft and farmers who count two to three times per week are more likely to experience livestock theft. The results suggest that farmers who count on a regular basis have a lower probability for the occurrence of livestock theft.

Results from the Truncated regression show (Table 4.13) that nine of the internal variables have a significant relationship with the level of livestock theft experienced by farmers in the Free State Province. Management practices that have a significant relationship with the level of stock theft experienced by farmers are: THEFT INFORMANT ($p<0.01$) and STRATEGIC THEFT INFORMANT ($p<0.10$). Taking into account the positive sign of the coefficient, farmers who are more likely to experience a higher level of livestock theft, make use of a stock theft informant (both actively and strategically). STRATEGIC CORRALLING ($p<0.01$) is the only physical barrier significantly related to the level of livestock theft experienced. The positive sign shows those farmers who have a probability of experiencing a higher level of livestock theft corral their animals during strategic times of the year. Two of the technologies used to control livestock theft were significant. Both STOCK THEFT COLLARS ($p<0.05$) and CAMERAS ($p<0.01$) proved to have a positive relationship to the level of livestock theft experienced. Thus, farmers who are more likely to experience a higher level of livestock theft use stock theft collars and farmers who have a higher probability of experiencing a higher level of livestock theft use cameras in and around their corrals.

As in the case of the occurrence of livestock theft (Probit), none of the animals used to control livestock theft proved to have a significant effect on the level of livestock theft experienced. Results show that the actions taken against stock theft contains four significant variables. ACTIVE PATROLS ($p<0.01$) and STRATEGIC ACCESS CONTROL ($p<0.10$) had positive coefficient implying that farmers who experience a higher level of livestock theft patrols throughout the year and farmers who are more likely to experience higher levels of stock theft, control access to their farms during known troublesome times. ACCESS CONTROL ($p<0.15$) and NEIGHBOURHOOD WATCH PATROLS ($p<0.10$) have had negative relationships with the level of livestock theft experienced. This implies that farmers who have access control to their farms and farmers who take part in neighbourhood watches experience lower levels of livestock theft.

From a management point of view it seems that farmers who count more often have a lower probability of experiencing livestock theft than those who count less often. This could be due to the fact that a farmer who counts his animals more often will become aware of theft at an earlier stage and thieves will have less time to get rid of the animals and/or evidence in their possession. Stock theft collars proved to be significantly related to the occurrence as well as the level of livestock theft with positive coefficients in both cases. Thus, farmers who have higher probability for the occurrence as well as the level of livestock theft, use stock theft collars. This could be an indication of how desperate the farmers, who lose large numbers of livestock on a regular basis, are to find a control method that works.

The signs and coefficients of the regression analyses shown in Table 4.12 and Table 4.13 suggest that farmers should count their animals on a daily basis to become aware of thefts as soon as possible. However, conclusions cannot be made based on these regressions. Even though variables with significant relationships to livestock theft in the Free State Province were identified by these regressions, the direction of causality is not given. Thus, it cannot be proved that farmers who take theft controlling actions or methods will lower their stock theft occurrences or levels of stock theft experienced. Causality testing is needed to statistically verify whether a change in control actions or methods will cause a change in the probability or the occurrence of level of livestock theft. Variables need to be significant for both the Probit/Truncated regression and the Granger Causality test before it can be concluded that the variable affects the occurrence/level of livestock theft in the Free State Province.

4.9 Pairwise Granger Causality test of significant external variables from the Probit regression

The Granger causality test was done to determine whether X “Granger causes” Y or *vice versa*. Results from the Granger causality test for the significant external variables affecting the occurrence of livestock theft identified in the Probit regression are presented in Table 4.14.

Table 4.14: Pairwise Granger Causality test of significant external variables from the Probit regression

Null Hypothesis:	Probability
Report within 0 – 1.99 hours does not Granger Cause Livestock Theft	0.4746
Livestock Theft does not Granger Cause Report within 0 – 1.99 hours	0.512
Report within 2.00 – 4.99 hours does not Granger Cause Livestock Theft	0.0389***
Livestock Theft does not Granger Cause Report within 2.00- 4.99 hours	0.6092
Report within 5.00 – 12.99 hours does not Granger Cause Livestock Theft	0.1427*
Livestock Theft does not Granger Cause Report within 5.00 – 12.99 hours	0.6195
Report within 13.00 – 24.00 hours does not Granger Cause Livestock Theft	0.0804**
Livestock Theft does not Granger Cause Report within 13.00 – 24.00 hours	0.5534
Pay workers on monthly basis does not Granger Cause Livestock Theft	0.4136
Livestock Theft does not Granger Cause Pay workers on monthly basis	0.2497
Plains does not Granger Cause Livestock Theft	0.5761
Livestock Theft does not Granger Cause Plains	0.1147*
Distance from town does not Granger Cause Livestock Theft	0.5943
Livestock Theft does not Granger Cause Distance from town	0.0823**
Border does not Granger Cause Livestock Theft	0.1206*
Livestock Theft does not Granger Cause Border	0.315

Note:

**** =statistical significance of 1%

*** =statistical significance of 5%

** =statistical significance of 10%

* =statistical significance of 15%

Result from the Granger Causality test (Table 4.14) show that REPORTING WITHIN 2.00 -4.99 HOURS ($p<0.05$), REPORTING WITHIN 5.00 – 12.99 HOURS ($p<0.15$) and REPORTING WITHIN 13.00 – 24.00 HOURS ($p<0.10$) all Granger Cause the occurrence of livestock theft. If these causalities are linked to the positive coefficient signs of the Probit model, it can be concluded that where farmers report thefts within 2.00 – 4.99 hours, 5.00 – 12.99 hours and 13.00 – 24.00 hours, the higher is the occurrence rate of livestock theft. Therefore, it can be concluded that farmers who take longer to report are more likely to experience the occurrence of livestock theft at a higher rate. The occurrence of livestock theft proved to be causing that more livestock is being farmed with on PLAINS ($p<0.15$). When joining the positive sign in the Probit model to the significant causality it will mean that higher occurrence rates of livestock theft cause more livestock is being farmed with on plains. Livestock theft proved to be Granger Causing DISTANCE FORM TOWN ($p<0.15$); this finding along with the positive sign of the coefficient in the Probit model will confirm that the occurrence of livestock theft Granger Cause that livestock are being farmed with further away from town. The Lesotho BORDER (p<0.15) proved to be Granger Causing the occurrence of livestock theft, the Probit model showed a positive sign thus, farms close to the Lesotho border had a higher rate of stock theft occurrences.

4.10 Pairwise Granger Causality test of significant external variables from Truncated regression

The Truncated regression was used to identify the external variables that have a significant relationship with the level of livestock theft, the causality must however, be tested with the Granger Causality test. Results from the causality test are shown in Table 4.15.

Table 4.15: Pairwise Granger Causality test of significant external variables from the Truncated regression

Null Hypothesis:	Probability
Report within 13.00 – 24.00 hours does not Granger Cause Livestock Theft	0.8451
Livestock Theft does not Granger Cause Report within 13.00 – 24.00 hours	0.0034****
Fulltime farmer does not Granger Cause Livestock Theft	0.6010
Livestock Theft does not Granger Cause Fulltime farmer	0.4581
Workers go to town every second weekend does not Granger Cause Livestock Theft	0.3589
Livestock Theft does not Granger Cause Workers go to town every second weekend	0.4342
Checking employees' history does not Granger Cause Livestock Theft	0.3566
Livestock Theft does not Granger Cause Checking employees' history	0.5663
Plains does not Granger Cause Livestock Theft	0.9911
Livestock Theft does not Granger Cause Plains	0.1570
Size of farm does not Granger Cause Livestock Theft	0.0123***
Livestock Theft does not Granger Cause Size of farm	0.9074

Note:

**** =statistical significance of 1%

*** =statistical significance of 5%

** =statistical significance of 10%

* =statistical significance of 15%

The Granger Causality results are presented in Table 4.15. The level of livestock theft proved to be causing that farmers REPORT WITHIN 13.00 – 24.00 HOURS (p<0.01). When linking the significance to the positive sign shown in the Truncated model it can be concluded that higher levels of livestock theft experienced by farmers "Granger Cause" their REPORTING WITHIN 13.00 – 24.00 HOURS. It seems that farmers have lost trust in the justice system and that they might feel it is not worth their while to report the thefts. These findings are similar to that of Statistics South Africa (2014a). The SIZE OF A FARM ($p<0.05$) proved to be Granger Causing the level of livestock theft experienced. This finding along with the positive sign of the coefficient in the Truncated regression will confirm that the larger th e farm is, the higher the level of stock theft experienced (larger numbers of animals stolen) and agrees with the findings of Bunei *et al.*, (2013). This could be due to the fact that in a case where two farms of different sizes experience the same stock theft rate (%) the number of animals lost on the larger farm will be more than that of the smaller farm resulting in a higher level on the larger farm.

4.11 Pairwise Granger Causality test of significant internal variables from Probit regression

Results from the Granger Causality test for the significant internal variables affecting the occurrence of livestock theft identified in the Probit regression are presented in Table 4.16.

Table 4.16: Pairwise Granger Causality test of significant internal variables from the Probit regression

Null Hypothesis:	Probability
Guards does not Granger Cause Livestock Theft	0.7993
Livestock Theft does not Granger Cause Guards	0.9734
Corral at night does not Granger Cause Livestock Theft	0.1391*
Livestock Theft does not Granger Cause Corral at night	0.0596**
Stock theft collars does not Granger Cause Livestock Theft	0.5974
Livestock Theft does not Granger Cause Stock theft collars	0.0593**
Lights in corral does not Granger Cause Livestock Theft	0.4935
Livestock Theft does not Granger Cause Lights in corral	0.5598
Alarm in corral does not Granger Cause Livestock Theft	0.4514
Livestock Theft does not Granger Cause Alarm in corral	0.9027
Strategic Collars does not Granger Cause Livestock Theft	0.8614
Livestock Theft does not Granger Cause Strategic Collars	0.7776
Count daily does not Granger Cause Livestock Theft	0.5341
Livestock Theft does not Granger Cause Count daily	0.6239
Count more than once per week does not Granger Cause Livestock Theft	0.0191***
Livestock Theft does not Granger Cause Count more than once per week	0.6586

Note:

**** =statistical significance of 1%
*** =statistical significance of 5%
** =statistical significance of 10%
* =statistical significance of 15%

Internal variables that have a significant relationship with the occurrence of livestock theft were identified in the Probit model (Table 4.13). However, results from the Granger Causality test (Table 4.16) indicate that not all significant internal variables form the Probit regression proved to have significant causal effects.

Three of the internal variables had significant causal effects toward the occurrence of livestock theft, namely: CORRALLING AT NIGHT, STOCK THEFT COLLARS and COUNTING MORE THAN ONCE PER WEEK. Interestingly, corralling at night has significant causal effects in both directions. Based on the results from the Granger Causality test and the Probit model it can be confirmed that sheep are corralled at night because of the occurrence of stock theft ($p<0.10$) and stock theft occurrences are caused by the corralling of sheep at night ($p<0.15$). Thus, it seems that farmers who have experienced livestock theft are corralling animals in an attempt to ensure their animals' safety; however, in some cases where animals are corralled it leads to higher occurrence rates of stock theft. This might be due to the fact that the animals are easier to catch in a smaller enclosed area.

Livestock theft proved to have "Granger caused" an increase in the use of stock theft collars ($p<0.10$). This is not surprising if taking into account that livestock stock theft collars are relatively new technology. That could be why the occurrence of livestock theft is causing the use of stock theft collars and it might still take time before we see that stock theft collars cause a decline in the occurrence of livestock theft. This also indicates how desperate livestock farmers are to control livestock theft.

Results indicated that counting animals more than once per week ($p<0.05$) "Granger Causes" the occurrence of livestock theft. Taking into account the positive relationship identified in the Probit model it can be confirmed that counting animals more than once per week, but not daily "Granger causes" higher occurrence rates of livestock theft. It seems that the informants to stock thieves or the thiesves themselves are aware that the animals are not counted on a daily basis and it will take longer for the farmer to realise that animals have been stolen. This should ensure that the thieves have enough time to remove the animals from the farm without being caught.

4.12 Pairwise Granger Causality test of significant internal variables from Truncated regression

Factors that have a significant relationship with the level of livestock theft experienced by farmers were identified in the truncated regression to ensure whether causality is present and a Granger Causality test is necessary. In Table 4.17 below the results from the causality test for the factors affecting the level of livestock theft are shown.

Table 4.17: Pairwise Granger Causality test of significant internal variables from the Truncated regression.

Null Hypothesis:	Probability
Neckless does not Granger Cause Livestock Theft	0.7493
Livestock Theft does not Granger Cause Neckless	0.3892
Camera does not Granger Cause Livestock Theft	0.7267
Livestock Theft does not Granger Cause Camera	0.3785
Theft informant does not Granger Cause Livestock Theft	0.4389
Livestock Theft does not Granger Cause Theft informant	0.8047
Active patrols does not Granger Cause Livestock Theft	0.4425
Livestock Theft does not Granger Cause Active patrols	0.8008
Access control does not Granger Cause Livestock Theft	0.6930
Livestock Theft does not Granger Cause Access control	0.9009
Strategic corralling does not Granger Cause Livestock Theft	0.6129
Livestock Theft does not Granger Cause Strategic corralling	0.6230
Strategic Theft informant does not Granger Cause Livestock Theft	0.5706
Livestock Theft does not Granger Cause Strategic Theft informant	0.4816
Strategic access control does not Granger Cause Livestock Theft	0.2225
Livestock Theft does not Granger Cause Strategic access control	0.5936
Neighbourhood watch patrols does not Granger Cause Livestock Theft	0.6147
Livestock Theft does not Granger Cause Neighbourhood watch patrols	0.3681

Note:

**** =statistical significance of 1%

*** =statistical significance of 5%

** =statistical significance of 10%

* =statistical significance of 15%

Although a number of internal variables proved to have a significant relationship with the level of livestock theft experienced by farmers (Table 4.13) none of these variables proved causal significance to the level of stock theft experienced by farmers (Table 4.17). Therefore, the level of stock theft will not change if these internal variables are changed. If recommendations are made only on results from the regressions it would not necessarily cause a decrease in the level of livestock theft experienced.

4.13 Summary and discussion

Results from the calculations show that annually livestock theft causes substantial losses to the sheep industry of the Free State Province. The Thabo Mofutsanyane district experienced the largest annual direct cost of the five districts. The highest annual loss rate was found in the Lejweleputswa district (5.98%). According to the data the annual direct cost of livestock theft in the Free State Province is estimated at R144 423 500 with 84 955 sheep lost annually. Investigation of the indirect cost representing the cost of control practices used to control livestock theft in the Free State Province indicated the highest annual indirect costs per sheep was found in the Lejweleputswa district (R33.76). The lowest annual indirect cost per sheep was determined for the Xhariep district (R3.81).

The three districts that experienced the highest loss rates spent the largest amount on control practices per sheep. This is a clear indication of how desperate farmers in the highly affected areas are to get livestock theft under control. Further investigation into control practices suggests that while farmers in the highly affected areas are spending much more on control methods (guards, stock theft collars, alarms, etc.), they do not spend substantially more on control actions (patrols, access control, counting, etc.) than the less affected districts. The district that experienced the largest annual indirect cost was the Thabo Mofutsanyane district (R11 298 523). Based on the calculations the total annual indirect cost of livestock theft in the Free State Province was calculated at R38 536 894. The total annual cost (direct cost + indirect cost) of livestock theft in the Free State Province is determined at R182 960 394.

The more common methods used by farmers in the Free State Province to control livestock theft are: corralling animals at night (47%), guards (13%), guard dogs (13.6%), stock theft collars (10%), cameras (5.8%) and alarms (3.4%). Actions taken by farmers to control livestock theft includes: patrols (63%), access control (33%), counting animals on a daily basis (55% includes counting twice daily), counting more than once a week (20%) and counting on a weekly basis (34%).

During investigation of the variables associated with livestock theft certain trends came to light. Farmers who reported stock theft cases normally experienced higher occurrences of livestock theft, it did not matter how long it took to report. Higher levels of stock theft, however, were associated with slower reporting of cases. Management of farm workers indicated that on farms where workers were paid on a monthly basis the occurrence rate of livestock theft was higher and where workers are taken to town every second weekend, lower levels of stock theft was experienced. Topographic variables showed that plains (flatter areas) experienced regular occurrences of stock theft, but at lower levels. Farms further away from town as well as farms close to the Lesotho border experienced stock theft on more occasions. Demographic variables showed that fulltime farmers experience lower levels of stock theft.

Investigation of the internal variables (control practices) showed that many control practices such as guards, stock theft collars, alarms and the corralling of animals, are being used because of regular occurrences of stock theft. The level of stock theft experienced led to the use of theft informants (actively and strategically), strategic use of stock theft collars, strategic corralling, cameras, patrolling actively and strategic access control. Placement of lights in the corral was associated with lower occurrence rates of stock theft. Control practices that proved to be associated with lower levels of stock theft was actively implementing access control and neighbourhood watch patrols. Where animals were not counted on a daily basis higher occurrence rates of livestock theft were experienced.

The variables that had a significant relationship with the occurrence and level of livestock theft as discussed above were identified in the Probit and Truncated model; however, to ensure that these variables had significant causal effect on livestock theft, Granger Causality testing was be done.

Results from the causality test suggest that farmers who take longer to report theft cases experience theft on a regular basis, but the level of stock theft experienced by farmers has also caused that some farmers take longer to report cases. Because of livestock theft, livestock are being farmed with further away from towns and on flatter areas of land (plains). Farmers might be keeping livestock away from towns so that they are out of sight of potential thieves. Keeping livestock on flatter areas (plains) might be so that suspicious activities could easily be detected and investigated. Larger farms experienced higher levels of livestock theft. On a larger farm it can be difficult for one farmer to keep an eye on each farming enterprise the whole time. One should also take into account that if a large and small farm experience, the same theft rate (%) the larger farm will experience a higher level of livestock theft.

Animals are being corralled at night because of the occurrence of livestock theft. However, the corralling of animals also leads to the occurrence of livestock theft. Thus, the corralling of animals at night might be an attempt to control livestock theft; however, the corralled animals are easier to catch in the confined space, creating more suitable conditions for thieves. The use of stock theft collars is the result of regular occurrences of stock theft and where animals are not counted on a daily basis, higher occurrence rates of stock theft are experienced.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The severe financial impact of livestock theft in the Free State Province is experienced by the livestock industry. In some cases livestock farmers have left the livestock industry due to livestock theft and moved to other farming enterprises. Official livestock theft statistics seem to be underestimated and limited information is available on variables affecting livestock theft. This study contributes to the information available on livestock theft, especially on sheep theft, and opens the field for further investigation into livestock theft in South Africa.

5.2 Meeting the objectives of this study

The primary objective of this study is to estimate the financial impact (direct cost + indirect cost) or implications of sheep theft in the Free State Province of South Africa. Sub-objectives were to estimate the direct and indirect cost of livestock theft losses and identify variables affecting the occurrence of sheep theft and the level of sheep theft.

5.2.1 Quantifying the direct cost of livestock theft

Results from the study indicates that the Lejweleputswa district municipality experienced the highest annual loss rate of 5.98% (Table 5.1) valued at R25 493 200 (14 996 sheep lost annually). This is double the annual loss rate of the Mangaung district municipality of 3.06% (1 404 sheep lost annually) valued at R2 386 800. These high loss rates indicate how serious the problem of livestock in these districts is. Much needed attention should be given to these districts to ensure that the annual loss rates can be reduced. The Xhariep district experienced the lowest annual loss rate of 0.96% amounting to a total annual direct cost of R32 000 800 (18 824 sheep lost annually). The relatively high total direct cost is the result of the large number of sheep in the district and not of the annual loss rate. The low loss rate however, could be an indication that farmers are controlling livestock theft more effectively. The fact that the Xhariep district has the smallest population could also be influencing the low loss rate (Table 4.3). Fewer people in the district will imply that the market for stolen animals or meat might be limited. The opposite can be said about the Lejweleputswa and Mangaung districts where their large populations could be creating the ideal conditions for selling stolen livestock (meat).

The highest annual direct cost of R43 076 300 was experienced in the Thabo Mofutsanyane district municipality with an annual loss rate of 2.31%. This is also the district municipality with the highest annual loss of sheep numbering 25 339. This is followed by the Fezile Dabi district municipality with an annual direct cost value of R41 466 400 with an annual loss rate of 1.68%, losing 24 392 sheep annually.

According to the data the total annual direct cost of livestock theft in the Free State Province was estimated at R144 423 500 with 84 955 sheep lost annually. This result indicates that the true impact of livestock theft is not accurately expressed in the official livestock theft statistics and is a matter of great concern. To put the annual direct cost into perspective, it is similar to approximately 14.15% of the annual Gross Farm Income that sheep production earns in the Free State Province (Statistics South Africa, 2007[11]). Part of the problem could be the fact that some farmers indicated that they do not report livestock theft cases. Sheep theft in the Free State Province also affects the governments' income in the sense that the tax that could have been earned with the sale of the animals is lost.

Table 5.1: The direct cost of livestock theft in the Free State Province per district

District municipality	Annual loss rate in the survey (%) (1)	Number of sheep within the province (2)	Total number of sheep lost annually in the province according to the survey (3) = (1x2)	Annual direct costs in the province according to the survey (R) (4)=(3xR1700[12])
Xhariep	0.96	1 960 874	18 824	32 000 800
Lejweleputswa	5.98	250 770	14 996	25 493 200
Thabo Mofutsanyane	2.31	1 096 944	25 339	43 076 300
Fezile Dabi	1.68	1 451 900	24 392	41 466 400
Mangaung	3.06	45 898	1 404	2 386 800
Total for province	-	4 806 386	84 955	144 423 500

Source: DAFF (2014a)

5.2.2 Quantifying the indirect cost of livestock theft

The annual indirect cost of livestock theft per district and per sheep is shown in Table 5.2. The indirect cost represents expenses associated with controlling livestock theft. The highest annual cost of control methods per sheep was found in the Lejweleputswa district municipality at R28.84

[11] Value given in Statistics South Africa (2007) and was inflation adjusted for calculation.
[12] Value provided by the National Stock Theft Forum in 2012.

which amounted to a total annual cost of control methods of R7 232 207. The Mangaung district had the second highest annual cost of control methods per sheep at R12.39; however, the small number of sheep in the district caused the total cost of methods to be the lowest of the five districts (R568 676). The Lejweleputswa district had the second highest total annual cost of methods at R7 232 207. The highest annual cost of actions per sheep was found in the Lejweleputswa district municipality at R4.92 and the total annual cost of actions taken was calculated at R1 233 788. Fezile Dabi district municipality had the second highest annual cost of actions per sheep (R3.71) and the largest annual total cost of actions of all the districts at R5 386 549. Even though the Xhariep district had the lowest annual cost of actions per sheep (R2.45) the large number of sheep in the district caused the total annual cost of actions to be the second highest (R4 804 141) of the five districts.

The largest indirect annual cost per sheep was found in the Lejweleputswa district (R33.76) with the total annual indirect cost amounting to R8 465 995, the third largest of the five districts. The second highest annual indirect cost per sheep was in the Mangaung district (R15.94). The highest total annual cost of actions were experienced in the Thabo Mofutsanyane district (R11 298 523) with the total annual indirect cost per sheep at R10.30. The second highest annual total indirect cost was calculated for the Fezile Dabi district (R10 569 832) with the annual total indirect cost per sheep at R7.28.

Interesting to see is that the Lejweleputswa district annually spent R33.76/sheep and experienced an annual loss rate of 5.98%, while the Xhariep district annually spent R3.81/sheep and experienced an annual loss rate of 0.96%. Thus, according to the data the Xhariep district has the lowest annual loss rate as well as the lowest annual indirect costs for controlling livestock theft. This could be an indication that the Xhariep district has a lower loss rate or that the district has fewer livestock thieves. It could also be an indication that the farmers are using the appropriate control practices and implementing the practices cost-effectively. However, as mentioned earlier other factors such as the small population (Table 4.3) and large size of the Xhariep district could be contributing to the low loss rate. The data suggests that the Lejweleputswa district should apply loss-controlling practices more effectively or reduce the practices used. According to the study the Lejweleputswa district annually spent the largest amount on control practices per animal (R33.76) while experiencing the highest annual loss rate (5.98%). This large amount of capital spent per animal could be an indication of how desperate farmers are to reduce the loss rate. It could also be an indication that the control practices that are used do not have an effect on the loss rate.

When comparing districts it can be seen that the costs of control actions taken by the farmers (patrols, access control, etc.) are closer to each other than the costs of control methods used. This could mean that farmers in all five districts are taking more or less the same amount of actions to control stock theft while methods used differ drastically between districts. The data suggests that farmers in the highly affected districts are desperate to control livestock theft and are spending large amounts of capital on control methods.

Table 5.2: The indirect cost of livestock theft in the Free State Province

District municipality	Method costs		Action costs		Total	
	Annual cost of methods per sheep in survey (R) (1)	Total annual cost of methods according to survey(R) (2)	Annual cost of actions per sheep in survey (R) (3)	Total annual cost of actions according to survey (R) (4)	Annual total indirect cost per sheep in survey (R) (5) = (1+3)	Total annual indirect cost according to survey (R) (6) = (2+4)
Xhariep	1.36	2 666 789	2.45	4 804 141	3.81	7 470 930
Lejweleputswa	28.84	7 232 207	4.92	1 233 788	33.76	8 465 995
Thabo Mofutsanyane	7.00	7 678 608	3.30	3 619 915	10.30	11 298 523
Fezile Dabi	3.57	5 183 283	3.71	5 386 549	7.28	10 569 832
Mangaung	12.39	568 676	3.55	162 938	15.94	731 614
Total	-	23 329 563	-	15 207 331		38 536 894

5.2.3 Determining the financial impact of livestock theft

The financial impact of livestock theft is calculated by adding the direct and indirect costs of livestock theft. The financial impact of livestock theft in the Free State Province is presented in Table 5.3. Based on the data the largest total annual cost of losses was experienced in the Thabo Mofutsanyane district (R54 374 823). Fezile Dabi experienced the second largest total annual cost of losses (R52 036 232). The total annual cost of losses for the Free State Province was calculated at R182 960 394.

Table 5.3: Total cost of livestock theft in the Free State Province

District municipality	Annual total direct cost of per district according to survey (R) (1)	Annual total indirect cost per district according to survey (R) (2)	Annual total cost of losses per district according to survey (R) (3) = (1+2)
Xhariep	32 000 800	7 470 930	39 471 730
Lejweleputswa	25 493 200	8 465 995	33 959 195
Thabo Mofutsanyane	43 076 300	11 298 523	54 374 823
Fezile Dabi	41 466 400	10 569 832	52 036 232
Mangaung	2 386 800	731 614	3 118 414
Total	144 423 500	38 536 894	182 960 394

This study has shed light on the seriousness of livestock theft in the Free State Province and opened the field for further research. This study also succeeded in calculating the indirect cost for livestock theft, but there are still other indirect costs that could be taken into account in the future such as: the replacement value of the lost livestock and interest of the lost livestock. The result suggests that the cost of livestock theft (sheep) in the Free State Province is less than the cost of sheep predation in the Free State Province (R237 205 338) (Van Niekerk, 2010); however, it is still a substantial amount. It causes grave concern to see that the number of sheep lost annually in the Free State Province according to the study, is more than four times the official number given for the province.

If these losses could have been prevented it would have had a positive effect of Gross Farm Income. This study is the first study that provided information on the total cost of sheep theft. Much has been speculated by farmers, researchers and other role players in the livestock industry on the impact that theft has on the livestock industry, but to date it has not been proven on a large scale. This research will now provide farmers and agricultural producer organizations with much needed information in order to formulate a case to the government. This study can serve as proof to the government on the cost that livestock theft has on the country. It can prove that livestock farmers need support regarding the management of livestock theft. If livestock theft cannot be controlled and other problems such as predation and bad weather condition keep on occurring, the future of South Africas' livestock industry will be threatened.

5.2.4 Identifying factors affecting livestock theft

The sub-objective to investigate factors affecting livestock theft in the Free State Province will shed light on the prevalence of livestock theft. Identified external and internal variables will help to understand which variables affect the occurrence and level of livestock theft experienced.

Investigation of the external variables proved that eight external variables were associated with the occurrence of livestock theft and six external variables showed a significant relationship to the level of livestock theft experienced. When focussing on the internal variables eight internal variables had a significant relationship to the occurrence of livestock theft, while nine internal variables were associated with the level of livestock theft experienced. Moreover, these results showed that variables (external and internal) affecting the occurrence of livestock theft and variables affecting the level of livestock theft are different. Thus, the results from this study relate to the results that Van Niekerk (2010) and Badenhorst (2014) reported for predation management. These variables that had a significant relationship with the probability of the occurrence of livestock theft and the level of livestock theft could not be used to determine if the variables are positively or negatively correlated with livestock theft. Thus, the identified relationship could not be used to make recommendations to farmers on how to control the occurrence and level of livestock theft since they do not give information regarding the directions of causality. Therefore, it was necessary to use the Granger Causality test with which external and internal variables could help to control livestock theft. If recommendations were made based only on these relationships, it would not necessarily cause a change in the occurrence or the level of livestock theft experienced.

Results from the Granger Causality test for the external variables suggest that the longer farmers take to report a theft, the higher the probability of the occurrence. The level of stock theft experienced, on the other hand, causes that farmers are taking longer to report stock theft cases. This could be related to the fact that some farmers indicated that they do not feel it is worth the effort to report theft cases. The occurrence of livestock theft causes that more livestock is being farmed with on plains. This could be so that farmers can easily check-up on their livestock and so that suspicious activity can easily be detected. Livestock farming is moving further away from urban areas probably in an attempt to lower the ease with which livestock can be stolen. It can also be to remove the livestock out of sight from potential livestock thieves. Farmers close the Lesotho border encounter livestock theft on a more regular basis than the rest of the Free State Province, though the level of livestock theft experienced is not significantly different from the rest of the research area. This could be an indication that farmers close to the Lesotho border pay more attention to preventing livestock theft and have been more successful in controlling the level of livestock theft experienced, though they are still struggling with the rate at which stock theft is occurring. The results suggest that larger farms experience higher levels of livestock theft but not significantly different rates of occurrence than smaller farms. This could be a case where a large and small farm might experience the same theft rate (%); however, the number of animals (level) stolen from the larger farm will be higher. The monetary value of losses will also be higher.

Causality testing for the internal variables indicated that many of the internal variables that had a significant relationship with livestock theft (Probit model & Truncated model) do not carry causal significance (Granger Causality test) to livestock theft. Methods used by farmers to control livestock theft showed that the corralling of sheep at night was caused by the regular occurrence of livestock theft, but in some cases the corralling of sheep at night caused that livestock theft occurred. This could be because farmers start to corral animals in an attempt to prevent the regular experienced thefts. But the corralled sheep are easier to catch in the smaller confined area, creating suitable conditions for livestock theft that increase the occurrence rates of stock theft. The use of stock theft collars proved to be caused by the occurrence of livestock theft and not *vice versa.* It therefore, seems that the use of stock theft collars is an attempt to reduce the occurrence of livestock theft and is reactive rather that proactive and relates to Barclay & Donnermeyer (2001). The only actions to control stock theft taken by farmers that proved to have a causal significance, is counting animals more than once per week that lead to higher rates of stock theft occurrences. It therefore seems that counting animals less often (not daily) provides the stock thieves with more time before the farmer realises his losses and acts, thus creating suitable conditions for livestock theft. The counting of livestock on a daily basis is not always possible. Other farm enterprises, e.g. maize, require more attention during certain times of the year, with the result that livestock management is neglected. It might also be that it is not possible because of the size of the farm or where animals are kept on different farms situated far from each other that make the counting of animals on a daily basis impossible. Part-time farmers might only have time to check livestock over weekends implying that livestock stolen early during the week could have been transported over vast distances before the farmer starts to act on the theft.

5.3 Limitations of the study

While the practices used to control livestock theft in the Free State Province was identified in this study, the cost benefit and effectiveness of each method and different action could not be determined. This could be the result of farmers who do not remember what amount of money was spent per method/action. The farmers were also wary of the purpose the information might be used for. The results were however, based on the information that was successfully captured. One of the possible solutions could be to sample a smaller area within the Free State Province where selected farmers are visited for a personal, follow-up questionnaire to capture the relevant information regarding each control practice. This study focusses only on the farmers' experience of livestock theft while in future it could be of great importance to link similar studies to questionnaires completed by the South African Police Service (SAPS). This will create a more holistic view of where the problems originate. The mixture of farming activities were not taken into account (e.g. livestock only, mixed farming grain and livestock) and could have played a role in affecting livestock theft. The mixture of farming activities could also be captured during a follow up questionnaire. The farmers that were contacted are all involved in organized agriculture (RPO).

5.4 Recommendations

It is recommended that support should be provided to livestock farmers either by government institutions, the South African Police Service (SAPS) and other agricultural businesses or organisations. If livestock theft is not successfully controlled, it will not only threaten the sustainability of the South African livestock industry but also the competitiveness of the industry. Management advice that can be formulated based on the study, is that livestock farmers especially (sheep farmers) should count their livestock on a daily basis. If the farmer is unable to count the livestock every day, a trusted herdsman or farm manager should be entrusted with the duty. Once farmers are aware of losses they should also report the cases immediately. This will ensure that thefts are detected as soon as possible, providing more time to recover the stolen livestock successfully either by the farmer himself or the South African Police Service (SAPS). Farmers on larger farms are advised to be more alert towards livestock theft. The herdsman or farm manager could also help with the detection and prevention of stock theft. In cases where livestock are corralled at night farmers should ensure that it does not lead to higher rates of livestock theft. Suspicious activity at night should be investigated as soon as the farmer becomes aware of it. It was found in the study that livestock is being farmed with further way from towns. It is recommended that farmers, Farmers' Unions and the SAPS or stock theft units work together to secure farms situated close to towns. Based on the total cost of livestock theft the Thabo Mofutsanyane district should be the first to receive attention to reduce livestock theft. If effective control practices are identified they should be used in the Lejweleputswa district to reduce the high theft rate.

From the result it is suggested that a higher level of management leads to lower livestock theft losses. However, in some part of the study area it does not seem that any control practice (action or method) help to successfully control livestock theft. Farmers are advised to report stock theft cases as soon as they become aware of it. By not reporting, farmers are doing more damage to the industry than good. If the number of animals stolen decline (because of non-reporting) the impact of livestock theft will seem to be decreasing and that less attention should be given by the government to control livestock theft. In cases were stolen animals are reported as soon as possible, it will ensure maximum time for the SAPS and stock theft unit to react ensuring maximum possibility of successfully retrieving the animals. Farmers' Unions and the SAPS or stock theft units should form reaction teams that can immediately act on suspicious activity and stock theft cases.

5.5 Suggestions for further research

Investigation of the whole process from when a livestock theft case is reported to the conviction of stock thieves is needed. Such research could help identify problematic or inefficient steps in the whole process. Research is required for detailed information regarding direct and indirect costs per specific control practice per area. Research that can prove the effectiveness of each control practice per specific area will be of great value to the livestock industry of South Africa. This could be achieved by means of a questionnaire that captures more details from farmers. If similar research could be done in the other provinces of South Africa it can serve as guidelines to livestock owners across the country to control livestock theft.

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