REASONS FOR POOR PRODUCTION AMONG THE EMERGING SMALL-SCALE PIG FARMERS OF THE LIMPOPO PROVINCE OF THE REPUBLIC OF SOUTH AFRICA.

by

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TABLE OF CONTENTS

DECLARATION

I declare that this work hereby submitted to the University of Pretoria for the degree of MMed Vet (Suil) has not been previously submitted by me for a degree at this or any other university, and the materials contained therein have been duly acknowledged.

Mokoele J M (NOVEMBER 2015)

ABSTRACT

Emerging small-scale pig farmers in Limpopo province perceive pig production and management as an important means of improving their livelihood and alternative investment option for the future. Their performance has not been optimal due to the lack of practical understanding of the basics of animal production, biosecurity and efficient production system.

Thus, an attempt was made to evaluate the challenges and constrains of pig farm production systems identified and reported by emerging small scale pig farmers (ESSPF) in the province. In addition, the risk factors associated with pig movement by ESSPF by means of spatio-temporal analysis was evaluated.

The study revealed that the average number of sows/farm was 7.4, while the number of boars/farm was 1.7. On average, the number of days that the sows take to return to oestrus from weaning was 42.9 days while the number of piglet's weaned/sow/year was 4.85 pigs. Also the study showed that 98.77% of ESSPF don't vaccinate their breeding stock against major pig diseases and only 2.47% ESSPF farmers had previously benefited from the infrastructure programme of the department referred to as Comprehensive Agricultural Support Programme (CASP). The majority of the respondents (82.61%) will prefer to sell their pigs at local points and within communities and only 9.32% and 14.09% will sell at the auctions or formal abattoir/supermarkets respectively.

It is therefore recommended CASP be evaluated to reach and impact more pig farmers positively. Good animal husbandry and transfer of knowledge by the veterinary officials is central to the growth of farmers and their productivity. The provision of regional slaughter facilities will reduce the travelling costs to Bronkhorstspruit and Belfast, but also reduce the likelihood of the disease spread within or outside the province.

The involvement of different stakeholders should be encouraged to ensure ESSPF are trained, mentored, coached, with the aim of improving their livelihood, food security and safety.

ABSTRAK

Limpopo provinsie is ‘n belangrike vark produseerende gebied met ‘n groot populasie van huishoudelike en wilde diere. Om die rede dien dit as ‘n interfase tussen huishoudelike diere, mense en wilde diere.Alhoewel opkomende varkboere in die provinsie die produksie en bestuur as ‘n belangrike verbetering in hul lewensbestaan asook alternatiewe finansiële beleggingsopsies vir die toekoms beskou, is hul prestasie nie optimaal nie as gevolg van die gebrek aan praktiese begrip van die basiese beginsels van diereproduksie, biosekuriteit en doeltreffende produksie stelsels. Dus, is 'n poging aangewend om die uitdagings en beperkings van varkplaas produksiestelsels te ïdentifiseer en die opkomende kleinskaalse varkboere (ESSPF) in die provinsie te evalueer. Bykomend is die risikofaktore wat verband hou met vark beweging deur ESSPF deur middel van tydruimtelike analise ontleed.

Die studie het getoon dat die gemiddelde aantal sôe per plaas was 7,4 terwyl die aantal bere per plaas 1,7 was. Die sôe neem gemiddeld 42,9 dae om terug te keer na estrus vanaf speen, terwyl die aantal varkies gespeen / sog / jaar is 4,85 varkies. Die studie het ook getoon dat 98,77% van ESSPF nie hul teeldiere ent teen die hoof vark siektes en slegs 2,47% ESSPF boere het voorheen voordeel getrek uit die program infrastruktuur van die departement verwys na as omvattende landbou-ondersteuningsprogram (CASP). Die meerderheid van die respondente (82,61%) verkies om hul varke by plaaslike punte binne gemeenskappe te verkoop en slegs 9,32% en 14,09% onderskeidelik verkoop by veilings of formele slagpale/ supermarkte.

Dit word dus aanbeveel dat CASP herevalueer om ‘n positiewe impak te bereik by meer varkboere. Goeie veeteelt en die oordrag van kennis deur die veeartseny-amptenare is sentraal tot die groei van die boere en hul produktiwiteit. Die voorsiening van plaaslike slaggeriewe sal die reiskoste na Bronkhorstspruit en Belfast (beide buite die provinsie en tans gekiesde slagpale van die ESSPF) verminder, maar ook die waarskynlikheid van die verspreiding van siektes binne of buite die provinsie verminder.

Die betrokkenheid van die verskillende belanghebbendes moet aangemoedig word om te verseker ESSPF opgelei word, gementor, afgerig, met die doel om van die verbetering van hul lewensbestaan, voedselsekuriteit en veiligheid.

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KEYWORDS

Emerging small-scale pig farmers, pig industry, efficiency index, poor performance, markets, movement control, African swine fever, biosecurity

LIST OF ABBREVIATIONS

AHT	Animal Health Technicians
ASF	African Swine Fever
CASP	Comprehensive Agricultural Support Programme
CSF	Classical Swine Fever
DAFF	Department of Agriculture, Forestry and Fisheries
ESSPF	Emerging Small-Scale Pig Farmers
LP	Limpopo Province
LDA	Limpopo Department of Agriculture
LSCPF	Large-Scale Commercial Pig Farmers
PRRS	Porcine Reproductive and Respiratory System
RSA	Republic of South Africa
SAPPO	South African Pork Producers Organisation
SV	State Veterinarian

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION AND OBJECTIVES

1. Pig farm production system

1.1 Definition and introduction of the ESSPF

Emerging Small-Scale Pig Farmers (ESSPF) are persons who are starting with a pig farming business venture. Since they are new entrants, they are learning to practice agrarian operations. Therefore an extension service is imperative to these group of farmers to teach them knowledge and skills in agricultural project operation (Sekokotla 2012).

According to the National Department of Agriculture (2006), Emerging Small-Scale Farmers (ESSF) is a relatively new term used to define previously underprivileged / disadvantaged farmers who are determined to become semi-commercial / commercial; these farmers have the potential to achieve this feat if they are offered adequate support. Chikazunga *et al.* (2007) assert that although this group of farmers consumes a portion of its produce, they produce mainly for commercialization. In South Africa, this group of farmers is comprised mainly of black farmers who were previously deprived of the opportunity to farm on a commercial scale during the previous era of governance.

1.2 Challenges faced by ESSPF

Emerging Small-Scale Pig Farmers still face difficulties of penetrating the already established markets and have limited resources for production. Kirsten *et al.* (1998) asserted that the challenges faced by ESSPF are likely to persist because the sector is not very well supported. With limited policy support, these farmers still face difficulties in both production and marketing of agricultural produce. Their main challenge is the land tenure, where they have permission to occupy the land, but they do not own the land (Chikazunga *et al.* 2007). Thus emerging farmers find it challenging to use their land as means of security for finance, resulting in hindered productivity and growth. They also face difficulties in accessing the

commercial formal markets because these markets don't serve their interests and therefore they use their different methods to sell their products (Chikazunga *et al.* 2007).

In South Africa, especially in the less developed rural areas, smallholder or emerging farmers have difficulty in participating in the commercial markets due to a range of technical and institutional constraints (Chikazunga *et al.* 2007). Factors such as poor infrastructure, lack of transport, lack of market information, insufficient expertise on product grading, poor farmer organization, inability to solicit contractual agreements, and poor organizational support, have led to inefficient use of markets by emerging farmers with resultant commercialization bottlenecks according to Chikazunga *et al.* (2007).

1.3 Government programmes to assist ESSPF

Some pig farmers in the province have been assisted by government in the recent past and this assistance has come in the form of access to information and markets, production inputs, infrastructure development, finance, prioritizing support and help associated with responses to natural disasters.

Department of Agriculture Forestry and Fishery (DAFF) in its strategic plan document 2014/2018 has developed food security programme which seeks to address infrastructure development, production interventions and improved market access to attain food security. This department allocated 2.9 billion rand in the medium term through CASP to provide for the infrastructure needs of 220 000 existing, 80 000 new smallholder producers and 380 000 subsistence producers (DAFF 2013).

The support provided, includes a mechanisation support programme that targets the subsistence and smallholder producers in order to increase their production, also pays for engineering consultants who give advice to farmer on proper usage of machinery and equipment's and offers engineering services.

This fund will also assist with the establishment and filling of posts that were vacant due to natural attrition. An additional 152.2 million rand was allocated to help with upgrading and

strengthening of provincial and rural agricultural colleges and additional 197 million rand was allocated for research, facilities, equipment and also increase student intake in the colleges (DAFF 2013).

Although this is a good initiative to have a one stop shop for smallholder farmers, focus has moved away from livestock production to crop farming through fetsa-tlala initiative. Fetsa tlala (eradicate hunger) is a government initiative that seeks to push back frontiers of hunger inadvertently working towards the elimination of the triple challenges of poverty, inequality and hunger, this is done by means of ensuring that fields are planted through the help of government tractors or private owned tractors and supply of farming inputs e.g. manure, seeds. This programme indeed has a great positive impact in the lives of crop farmers but however, this may cause some challenges in the future as livestock farmers will start complaining about neglect, because in this medium term fetsa-tlala was not budgeted for and as such 70% of CASP budget needs to cover fetsa-tlala expenditure.

1.4 The general importance of pig farming

Emerging Small-Scale Pig Farmers perceive pig production and management as an important means of improving their livelihood and as well as an alternative investment option for the future, pigs also contribute to human nutrition, food security, poverty alleviation, and creation of employment for the rural community (Mergenthaler, Weinberger & Qaim 2009; Dietze 2011; Antwi & Seahlodi 2011). In addition, pigs provide a less expensive source of animal protein compared with cattle, sheep and goats for urban consumers. While pig farming as part of animal agriculture is central to the development of rural farmers; the real contribution of ESSPF to the sectoral economy is not well assessed and somewhat doubtful. These economic contributions by this group of farmers are faced with management, health, housing, feeding and marketing constraints (Ironkwe & Amefule 2008).

1.5 The relevance of the Limpopo province in pig production in South Africa

In South Africa, it is further suggested that there are approximately 125 000 production sows in 2010 / 2011 with approximately 100 000 sows being held commercially while the

remaining 25 000 are kept by small-scale farmers. Approximately 1 200 ESSPF exist country wide with the mean sow units consisting of 10-20 sows (DAFF 2012; Mashala 2012). The South African pork industry contributes around 2.15% to the primary agricultural sector, and over 2.4 million pigs were slaughtered during 2011, the total pork production was put at 203 375 tonnes in cold dressed mass (DAFF 2014). Although South Africa is regarded as self-sufficient in pork production, the country still imports more pork than it exports because of the high need for processed pork products like ribs (Mashala 2012).

Limpopo is the leading commercial pig producing province in South Africa contributing approximately 24% of the total pig production in 2011 (DAFF 2012), however, only about 11 700 of all the sows in the province are registered as commercial sows with a widespread distribution of non-registered and unorganised small to medium-scale pig farms. Previous studies have indicated that Limpopo played a key role in some transboundary animal disease disseminations in view of its location and contiguous boundaries with other countries and is responsible almost exclusively for outbreaks of African Swine Fever (ASF) into South Africa (Boschoff 2007). Since all the index cases to date of outbreaks of ASF in South Africa have originated from Limpopo province and the majority of these outbreaks were linked with small-scale pig farms, it is critical to understand the management and production systems of this category of farms in order to effectively carry out proactive disease prevention and management.

1.6 The important control zone of ASF diseases in the province

Globally, infectious and zoonotic disease outbreaks have particularly intensified in past decades at a rapid pace in view of more intense interconnectedness, rapid transport, opening-up of borders and increasing volumes of legal and illegal trades (Perry, Grace & Sones 2013; Jones *et al.* 2013). Spatio-temporal analyses including social network analyses are disciplines traditionally entrenched in the field of geography and geo-informatics but have in recent times found relevance in the field of medicine, veterinary medicine, infectious diseases and microbiology just to mention a few (Jiang, Ediger & Bader 2009; Rivas *et al.* 2012; Paul & Dasgupta 2012). Specifically, geographic factors such as roads, water bodies, distances from other outbreaks and markets among others have been found

to play important roles in disease transmission and spread (Jori *et al.* 2009; Rivas *et al.* 2010; Rivas *et al.* 2012; Sanchez-Vizcaino et al. 2012, FAO 2013; Pastrana *et al.* 2014; Korennoy *et al.* 2014).

The province of Limpopo is regarded as a control zone for ASF alongside with parts of the North West and Mpumalanga and Kwazulu-Natal (Penrith 2013) (Figures 1a & b). Furthermore, the province serves as an interface where activities between the domestic animal-human-wildlife interfaces are very common, making it a peculiar location for studies involving one-health, zoonoses or wildlife-domestic animal diseases.

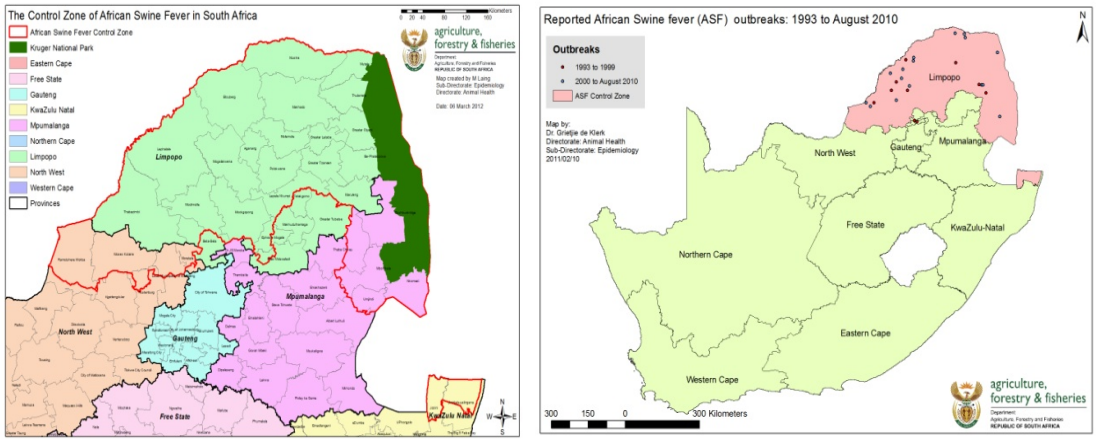

Figure 1(a) Map of South Africa showing the ASF control zone (red-line) and (b) Reported outbreaks in Limpopo between the year 1993 and 2010.

1.7 Risks related to market opportunities outside the province

Pig production systems and the particular contributions of the ESSPF in the province have been described recently (Mokoele *et al.* 2014). However, the presence of a deep-rooted dual-market structure remains a major challenge facing small-scale pig producers in the province (Antwi & Seahlodi 2011). While the commercial pig farmers utilize the formal markets (standard abattoirs, processors and supermarkets), the ESSP farmers mainly access the informal markets (local auctions, backyard slaughters, pension sale points and local abattoirs/slaughter slabs) as asserted by Antwi & Seahlodi (2011).

The most popular auction point and abattoir used by the ESSPF from Limpopo are Belfast (Mpumalanga) and Bronkhorstspruit (Gauteng). These locations present the ESSPF with

better marketing opportunities and higher incomes for their products. However, although the commercial interests of the ESSPF are being secured, breach of biosecurity remains evident and the risk of introduction of infectious pathogens to non-endemic areas are high and these pose imminent threats to the pig industry nationally. Martinez-Lopez, Perez & Sanchez-Vizcaino (2009) and Lindstrom *et al.* (2009) have previously identified shipment of pigs from one area into another as a major risk that may result in diseases outbreaks.

2. Hypothesis

Certain factors limit production, marketing of pigs and present health challenges to the emerging small scale pig farming units in Limpopo, South Africa.

3. Objectives

The objectives are to:

3.1 To describe the pig farm production systems, determine constraints/challenges identified and reported by ESSPF in Limpopo Province.

3.2 To use spatio-temporal analyses to determine the geographic and other risk factors associated with the movement of pigs by ESSPF in Limpopo Province.

CHAPTER 2: LITERATURE REVIEW

2.1 Categories of pig farmers in South Africa

The South African pig farming communities are categorized into the following:

- Back-yard pig farmers are subsistence farmers who keep indigenous breeds and feed pigs mainly on swill, sometimes with little or no supplementation.
- Emerging Small-Scale Pig Farmers (ESSPF) or Emerging Small-Holder Pig Farmers (ESHPF) are basically farmers who keep pigs for both subsistence and commercial purposes, with more emphasis on the latter (FAO 2010). They breed a specific type of pig and have greater abilities to grow than the group above; in South Africa ESSPF may have 1 to 50 sow units. Pork is supplied to local markets and to more distant urban markets, through a multifaceted transport and marketing system.
- Medium-Scale Commercial Pig Farmers (MSCPF) is commercial farmers, who are breed-specific and have greater than 50 and up to 250 sows as a barrier concern.
- Large-Scale Commercial Pig Farmers (LSCPF) operates on a contract basis with abattoirs and has greater than 250 sows on the unit (SAPPO 2012).

2.2 Factors affecting productivity of ESSPF

2.2.1 Record keeping:

South African's ESSF are notorious for their poor record keeping practices as emphasized by Groenewald (2004). This attitude towards record keeping and a lack of professional business practices has led many researchers to presume these farmers to be illiterate or semi-illiterate. These challenges impact negatively on the assessment of business viability because it may be quite difficult if not impossible to objectively determine the actual profit of the enterprises (Groenewald 2003).

2.2.2 Biosecurity on a pig farm:

This practice is very poor among the majority of the ESSPF and its non-adherence usually leads to the introduction of disease in ESSP farms (Fasina *et al.* 2012a). Biosecurity measures applicable to pig farms are classified into three steps:

Segregation is the first and most important element of biosecurity. It involves keeping potentially infected animals and materials away from uninfected animals. It is also regarded as the most effective step in achieving the required levels of biosecurity; if a pathogen does not enter a property or piggery, no infection can take place. No animals or materials should enter or leave a piggery unless absolutely necessary: this includes not only pigs, but also other species (including humans) that may be infected or contaminated with pathogens and that can also infect pigs. Segregation includes the enforcement of the change of footwear and clothing for all people that cross the barrier, and restricting the entry of vehicles, by erection of fences and gate. It is therefore the basis of most biosecurity measures, from the farm-gate to the individual pig pen (FAO 2010).

Cleaning is the second most important step of biosecurity, which includes sweeping daily, washing of the empty pen with a copious amount of water, thorough washing with soap, water and a brush to ensure that there is no visible dirt on the surface of buildings and materials, and the pens should be allowed to dry after this important step (FAO 2010; Fasina *et al.* 2012a).

It is important that disinfection be performed consistently and accurately, but should be regarded as a final “polishing” step in biosecurity and it is used after effective and comprehensive cleaning. Disinfectants will not necessarily penetrate dirt in sufficiently high concentrations, nor will they be present for sufficient time to be effective. They are inactivated by organic materials such as wood or faecal material. Thus, although this is the final important step, it can be regarded as the least effective step in biosecurity (FAO 2010).

2.2.3 Markets and related challenges

Marketing is a business activity associated with a flow of goods and services from producers to consumers (Antwi & Seahlodi 2011). The marketing of agricultural products in particular begins on the farm, with planning of production to meet specific demand and market prospects.

The South African Government's agricultural marketing policies play a fundamental role in promoting pig enterprises for ESSPF. Marketing of agricultural products (especially pigs and their products) is important among the ESSPF, due to benefits such as food security, income and rural employment (Ngqangweni 2000).

Antwi & Seahlodi (2011) asserted that the South African pig industry currently has a dual market structure: formal markets (processors and abattoirs) for commercial pig farmers and informal markets (local auctions, pension point sales and supermarkets) for the ESSPF. Formal markets have clearly defined grades, quality standards, safety regulations and prices are formally set (Antwi & Seahlodi 2011). Thus formal markets pay premium price for quality products and are accessed by big commercial farmers, while ESSPF find it difficult, but must in the medium term penetrate these formal markets. The major issues with regard to the ESSPF in accessing or penetrating the formal markets include: (Antwi & Seahlodi 2011).

- Lack of knowledge and use of market information
- Lack of access to high-value reliable markets and high transactional costs
- Long distance from the markets which tends to influence transactional costs, high feed costs, price and competition
- Lack of appropriate and affordable means of transport
- Lack of storage facilities
- Adverse effects of culture and socio-economic factors
- Low educational levels of small-scale and emerging farmers
- Imposed agricultural marketing policies
- Poor agricultural extension services

- Lack of financial support.

2.2.4 Extension and training services for farmers

Communication of new technologies, ideas and practices is the primary role of extension agents. Most of the time ESSPF are not involved with extension agents and are therefore deficient in acquiring the necessary information about new technology, skills, innovations and production advice (Chaminuka *et al.* 2008). Although the services of the extension agents are available in South Africa, their use by ESSPF is poor due to cost and sometimes the technicalities involved (Chaminuka *et al.* 2008). At the same time Montshwe (2006) has emphasized that ESSF have difficulties in accessing market information, and are thus exposed to a marketing disadvantage. They rely on informal networks (traders, friends and relatives) for market information due to weak public information systems, which may expose them to biased information due to opportunistic behaviours of the informed group (Mabuza & Ngubane 2010).

2.2.5 Water

Water is a critical resource in any pig production unit, as it is required for cleaning the pens, drinking purposes and cooling of the pigs. In most of these units, pigs get water only twice a day, in the morning and in the afternoon. In certain piggeries they are supplied with water every other day. Limited water accessibility has negative effects on the pig as it retards their growth potential and affects many other biochemical process (Manchidi 2009). The increased the distance between the household / production site from the water source results in a lower probability of the household being involved in pig farming activity, and if they do engage in farming activity, this will translate into higher capital cost for that particular farmer (Mabuza & Ngubane 2010).

2.2.6 Nutrition

Generally feed accounts for up to 70% of production cost in the piggery. The quality of feed determines the productivity of the entire herd. Pigs require the six general classes of nutrients: carbohydrates, fats, protein (amino acids), minerals, vitamins and water. Energy is an important nutrient for the body's fuel and is crucial for growth and important for movement such as walking, eating and for engaging in all the energy-intensive activities of the pigs. Fats and oils can also be fed to supply energy, to increase palatability and also to improve feed efficiency and as wellbeing a source of essential fatty acids (linolenic acid, linoleic acid and arachidonic acid), but they only add to the value of energy from carbohydrate and should not be the main source (Pretorius 2007).

Proteins provide the material from which pigs produce lean muscle, reproductive cells and also repair body tissue. Each protein is made up of several simpler compounds called amino acids. Lysine is the essential amino acid in swine rations. Vitamins and minerals are important for other physio-biochemical and metabolic process in the body of a pig (Carrington 2004).

The main challenge facing ESSPF is that feed suppliers are mostly located around peri-urban areas whereas ESSPF are mainly located in the rural areas where they do not have good means of transport to collect feed and in addition, the high cost of these feeds acts as a disadvantage for the emerging farmers. No uniform template is available for the feeding of pigs in and around rural areas. Pigs are only fed based on availability of resources (kitchen and hospital wastes, and other such remnants). These remnants may be substituted at times with wheaten bran, maize, concentrates and vegetables (Manchidi 2009).

2.2.7 Management of the sows and boars

Small-scale piggeries don't have formal management programmes. This is partly due to inadequate advice from government extension services as well as from inadequate infrastructure. The boars and the sows are normally housed together most of the time

resulting in loss of interest due to a reduced level of libido or exhaustion (Manchidi 2009). There is a lack of proper weaning and breeding strategy, to the extent that this results in a number of undesirable consequences which may include amongst others, increased weaning to service interval, increased empty days/sow/annum, reduced number of mating's per week, less number piglets born and most importantly this will affect the total number of piglets weaned/sow/year (Fasina 2012).

2.2.8 Housing

Housing often becomes a major challenge in ESSPF as most of them are still starting-up and therefore lack enough funds to invest in good infrastructure. These farmers are forced to house pigs of different production stages together with limited feeding space and poor drinking facilities, resulting in frequent fights during feeding and other behavioural problems (Manchidi 2009).

These fights normally result in injuries and wounds. The pigs compete for feed and water, which will result in the young pigs getting inadequate / less feed and water. Smaller pigs under this circumstance will grow slower than normal and therefore reach marketable stage after a prolonged period, which results in this farming endeavour becoming very costly and unsustainable (Manchidi 2009).

2.2.9 Diseases and pre-weaning losses

Emerging Small-Scale Pig Farmers face challenges of piglet mortalities as are present in commercial pig farms, but ESSPF are customarily affected by this situation. The piglet mortalities are mainly caused by lack of colostrum in the first 24 hours after birth. The other very critical factor is hypothermia. These farms lack heating facilities resulting in greater challenges during the cold winter months of the country. The lack of a proper farrowing house and proper amenities result in increased mortalities due to crushing of the piglets (Shankar *et al.* 2009; Mokoele *et al.* 2014).

Mange and lice infestation are important conditions that cause considerable losses because of the extreme itching and continuous scratching of the skin (Ironkwe & Amefule 2008). The other diseases of importance to the pigs of the ESSPF are *Escherichia coli* diarrhoea and coccidiosis caused by *Isospora suis* (Kammersgaard *et al.* 2011). *Escherichia coli* is a very important bacterium that causes diarrhoea in piglets. Diarrhoea can occur at any age during suckling but there are often two peak periods, before 5 days and between 7 and 14 days. Coccidia-affected faeces caused by *Isospora suis* vary in consistency and colour from yellow to green, or bloody according to the severity of the condition (Kammersgaard *et al.* 2011; Fasina 2012).

CHAPTER 3: MATERIALS AND METHODS

3.1 Pig farm production systems constraints and challenges

3.1.1 Introduction to material and methods

According to Thrusfield (1995), a scientific study ought to be an investigative process that employs the right research methodologies. Steyn *et al.* (1994) affirm that survey research is to be initiated by selecting the proper sampling method, followed by the design of the questionnaire and data collection through interviews of respondents by field workers who are trained at a workshop to do the interview.

3.1.2 Study area

The study was conducted in the five districts of Limpopo Province of the Republic of South Africa (RSA), namely Sekhukhune, Capricorn, Waterberg, Vhembe and Mopani districts. This province serves as an interface where activities between the domestic animal-human-wildlife interfaces are very common and most importantly is an ASF control zone and also very important in terms of pig populations with regards to other provinces for both commercial and emerging small scale pig farms.

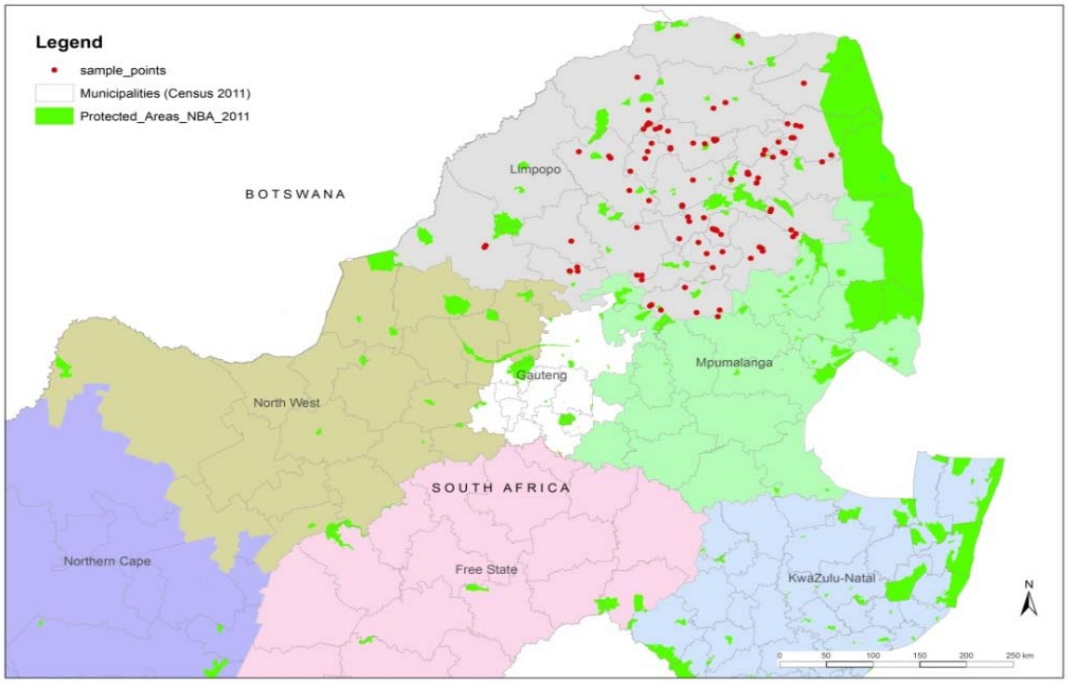

Figure 2: Map of Limpopo province showing study site between the year 2012-2013.

3.1.3 Sampling methods

The research was divided into the following phases:

- Planning of the study
- Planning and compilation of the questionnaire
- Once the questionnaire was decided upon then phases include:

Phase 1: Initial plenary meetings

Meetings were convened and held to discuss research plan and its benefit with the veterinary and extension officers and also to enlighten them about the list of ESSPF to be involved in the study and also conducted training for interviewers in this phase.

Phase 2: Farmer interview

Selected farmers were interviewed (face-to-face) using a semi-structured questionnaire for data collection in their preferred language. The semi-structured questionnaire was to collect both qualitative and quantitative data. Bless & Smith (2000) asserted that an interviewer-administered interview is an important tool of data collection because it reduces the problems of words or the question of misinterpretation (misunderstanding) by respondents and can be administered to farmers who can neither read nor write. In addition, the presence of the interviewer increases the quality of the response since the interviewer can probe for more specific answers (Leedy *et al.* 2004). However, efforts were made to reduce courtesy and opinion biases on the part of interviewer by allowing farmers opportunity to give their answers freely and the prior training of the interviewers became important to ensure that interviews are done effectively and efficiently.

Phase 3: Analysis of farmers' questionnaires

Analysis of farmer's questionnaires was conducted in phase 3 with the help of a pig veterinarian with knowledge of Microsoft Excel®. Descriptive statistics as well as students' T test, Chi square, ANOVA and other appropriate analytic methods were used.

Phase 4: Report Compilation

In phase 4 a research study report will be synthesized and be submitted to the Faculty of Veterinary Sciences, University of Pretoria and other applicable organizations.

Phase 5: Report back to stakeholders

A feedback session on veterinary extension, best practices of pig production systems to farmers, veterinary and extension officials was done at various platforms including workshops, meetings, farmers days, agricultural and veterinary conferences.

3.1.4 Data collection

A semi-structured questionnaire (Appendix 1) was designed at the Department of Production Animal Studies, University of Pretoria based on available literature, expert opinions and fitting primary objectives of the study. This was pilot tested amongst veterinary students (n=12) and was later reviewed and validated by selected pig veterinarians in the field, the Research Committees of Limpopo Department of Agriculture and the Faculty of Veterinary Science, University of Pretoria as well as State Veterinarians (SV) and Animal Health Technicians (AHT) of the department during organised districts consultative forums. The questionnaire was used to collect data from the selected participants using participatory method as described by Thrusfield (1995).

This instrument was designed to capture data on factors that affect production performance of the ESSPF with particular reference to the province. The data collected includes: (Appendix 1)

- Biographical information data (name, age, sex, highest educational level attained, family size and the vision of the farm / production unit);
- Production and marketing factors (management of the production, marketing strategy, health plan, housing, and feeding strategy);
- Perceived problems.

All questions were prepared in English and translated / administered in the farmers' home language and in a semi structured manner through the help veterinary and extension official employed by Limpopo Department of Agriculture.

3.1.5 Sampling frame and strategy

The LDA have partially documented records (n = 85) of ESSPF and this department is on the drive to fully document the records of these pig farmers so that targeted interventions in

terms of infrastructure development, veterinary extension services, production and marketing inputs can be carefully planned to assist these farmers.

A purposive sampling method was used to select ESSPF (n=185) from the study sites including the 85 small scale pig farmers enlisted on the Province's Department of Agriculture list and an additional 100 farms that fall within this category but were not listed. The expansion of the list beyond the Department list became necessary because the preliminary data from the field had suggested that there were many unlisted ESSPF in the province (Steyn *et al.* 1994) and observation from the field proves the sentiment to be true. The inclusion criteria was pig farms with ≤50 sow-unit located within the five districts of Limpopo that have been active in pig production for at least one year. A participatory research model approach was used (Chambers *et al.* 1993; Thrusfield 1995).

3.1.6 Data management and analyses

A total of 185 questionnaires were collected from the field but 20 were filtered out due to missing values and inconsistent data. Another respondent was removed since he had increased his herd size to a 150 sow unit. A total of 164 respondents (88.65%) were included in the analysis. The data from completed questionnaires were coded, captured and filtered using Microsoft Excel® spreadsheet and descriptive statistics were performed. The analyses performed include proportional percentages, measures of central tendencies, percentiles, and graphs of farm characteristics, production parameters, management and health parameters and operational efficiencies using STATA v9.0 (Stata Corporation, Lakeway Drive, College Station, Texas, USA). Efficiency indices for piglets weaned per sow and for average days to oestrus were calculated by dividing the category mean by mean total number of sows for the category. Correlation coefficients were calculated for farm parameters that were thought to influence one another in the analyzed data.

3.2 Spatio-temporal analyses of movement variables

3.2.1 Geo-coordinates data collection

The geo-coordinates of all surveyed ESSPF were obtained and entered into a Microsoft Excel® spreadsheet using the Garmin Nuvi® or the Nokia Lumia 635®. All data were entered into Microsoft Excel® and checked for consistency, correctness and validity. A preliminary map was drawn to check that all places surveyed fall within the correct locations within Limpopo based on the data obtained. Data were formatted to meet the need for cartography software in ESRI's ArcGIS/ArcView and the NodeXL software and exported appropriately.

3.2.2 Cartography, point mapping and one-way linkages

ESRI's ArcGIS 10.1 software was used to add all specified geographic coordinates of the ESSP farmers as XY coordinate data into the GIS.

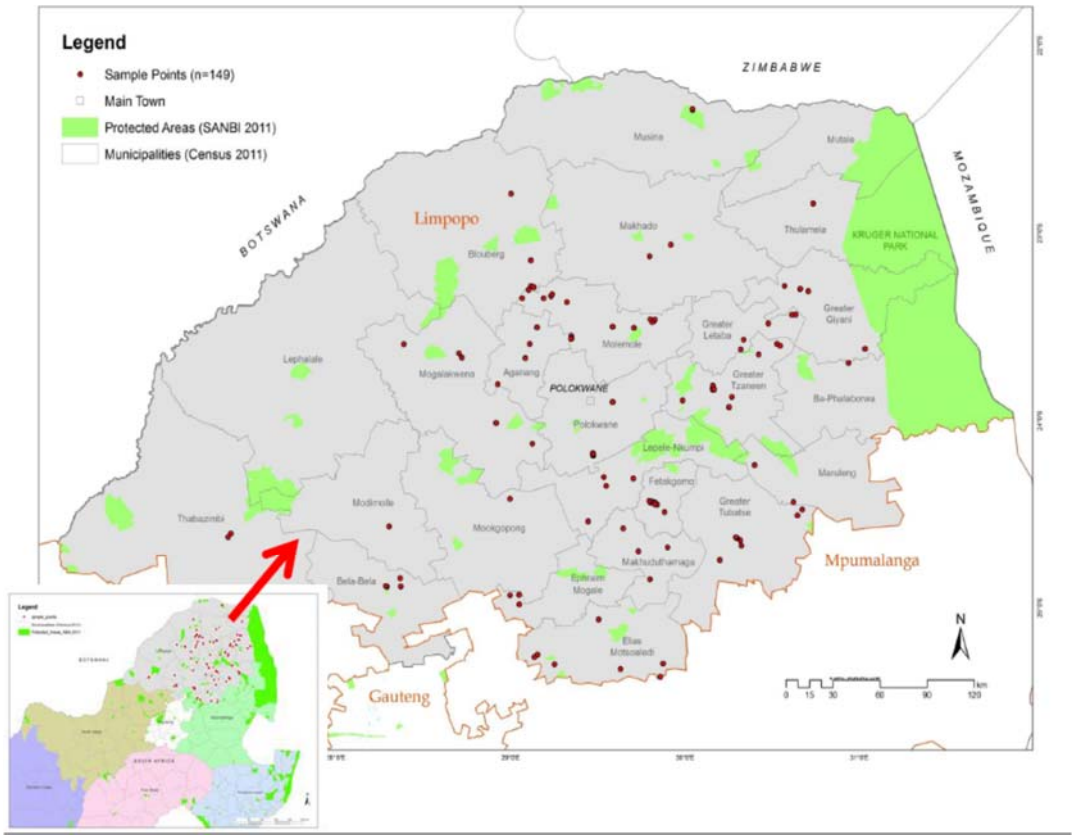

Figure 3: Map of surveyed locations of ESSPF in Limpopo 2012

The smaller map indicates Limpopo with contiguous provinces of North-West, Gauteng, Mpumalanga, and some other provinces (Northern Cape, Free State and Kwazulu-Natal). The call-out map clearly indicates the districts and municipalities within Limpopo and the spread of sampled sites

The resulting event layer was then displayed as a point symbol (red dot) portraying the locations of the small-scale pig farmers on an administrative map of Limpopo (Fig 3).

Additional fields were added to the initial attribute table of the feature to enable selection of farms by their designated abattoir of choice. Thereafter the 'XY To Line' feature tool was used to construct geodetic lines/linkages [(Figure 8 (a) & (b)] representing the shortest distance between the farm and the destination point (the abattoir or auction point). Pig farmers who used local slaughtering points are represented by a symbol (red dot) on these two maps.

3.2.3 Social network analyses

Filtered data was imported from the open Microsoft Excel® workbook into the NodeXL environment and manipulated appropriately for analyses based on software manufacturer's instructions (NodeXL Version: 1.0.1.326, Connected Action). The graphs produced were unidirectional with 28 vertices. The graph's vertices were grouped by cluster using the Clauset-Newman-Moore cluster algorithm and laid out using the Harel-Koren Fast Multiscale layout algorithm. The edge colours, widths and opacity were based on edge weight values. The vertex sizes were based on betweenness centrality values. For emphasis, graph/network is a set of vertices and edges connected together [G = (V, E)], edge [E] is an association linking two vertices and vertices [V] are points/locations joined by edges (Jiang, Ediger & Bader 2009).

CHAPTER 4: RESULTS

4.1 Pig farm production systems constraints and challenges

4.1.1 Production system challenges or constraints results

In this study, it has been proved that male farmers represented the majority of the participating respondents (76.83%), a reflection of the population structure amongst the ESSPF in the province (Table 1). Similarly, farmers whose age falls in ≥ 46 years old were 78.53% of the total respondents and only 5.52% were ≤ 35 and 15.95% were 36-45 years old. In addition, a total of 77.78% of the respondents were married (Table 1). The majority of the farmers interviewed (63.80%) were engaged fulltime in their pig farming activities while only 26.90% were involved part-time. It was further noted that 26.54% of the total respondents have post-matriculation qualifications. In this study, the definition of breeds were based on phenotypic characteristics of the pigs observed on the farm, therefore, 61.18% of the breeds used were indigenous/undefined, 28.29% were Large White, 10.53% were Landrace and only 7.24% were Duroc breeds (Table 1). Only 2.47% ESSPF farmers had previously benefited from the infrastructure programme of the department referred to as CASP.

Table 1 Characteristics of ESSPF in Limpopo

Characteristics (number of respondents)	Variables	% of respondents
Gender (164)	Male	76.83
	Female	23.17
Age category in years (163)	< 25	2.45
	26-35	3.07
	36-45	15.95
	46-55	33.13
	56-65	32.52
	>65	12.88
Marital status (162)	Single	11.73
	Married	77.78
	Divorced	2.47
	Widow	5.56
	Not specified	2.47
District Municipalities (161)	Sekhukhune	27.95
	Capricorn	30.43
	Mopani	26.71
	Vhembe	4.35
	Waterberg	10.56
Land ownership (163)	Own	50.31
	Lease	7.36
	Communal	39.26
	Others	3.68
Highest level of education (162)	Primary school	13.58
	High school	27.16
	Completed grade 12	17.90
	Post-secondary	26.54
	Others/informal education	14.81
Participation in farming (163)	Full time	63.80
	Part time	26.99
	Not defined	9.20
Breeds of pigs kept (152)	Large White*	28.29
	Landrace*	10.53
	Duroc*	7.24
	Indigenous/undefined	61.18
Received financial assistance or inputs from government (162)	No	97.53
	Yes	2.47

**Pig breeds were based only on phenotypic characteristics of the breed types. E.g. erect ears, long body, compact shape, brown colour, droopy ears.*

The average number of sow/farm is 7.4, while the number of boars/farm is 1.7. On average, the number of days that the sows take to return to oestrus from weaning was 42.9 days while the number of piglet's weaned/sows/year is 4.85 pigs (Table 2).

Table 2 Characteristics of ESSPF in Limpopo, South Africa

	Mean±SD	Median	1 percentile	25 percentile	75 percentile	95 percentile	99 percentile
Number of sows/farm (151)	7.4±7.8	5	1	3	8	25	40
Number of boars/farm (133)	1.7±1.4	1	0	1	2	5	7
Number of days to return to oestrus (sows) (112)	42.9±46.1	21	3	14	60	180	210
Average number of piglets weaned/ sow/year (115)	4.85±4.6	3.4	<1	1.67	6	15.88	18

The majority of the respondents (92.36 %) did not provide a heat source for their piglets especially in the cold winter months and this has greatly impacted on increased levels of mortality. In addition, 44.0% lost piglets primarily due to overlay and hypothermia while 62.67% claimed that piglets were lost principally due to other causes e.g diarrhoea, thieves and cannibalism (Table 3). The interviewed farmers complained about skin conditions in their herds and approximately 46.84% of the respondents identified skin diseases (primarily mange) as the most important disease complex in their farms (Table 3). Other disease complexes that were rated low by the farmers included reproductive (12.66%), enteric (8.86%), respiratory (6.33%), musculo-skeletal (5.06%) and mixed infections (39.87%) (Table 3).

Table 3 Management and health parameters of ESSPF in Limpopo, South Africa

Characteristics (number of respondents)		% of respondents
Provide heat source for piglets (157)	No	92.36
	Yes	7.64
Lead reason for pre-weaning mortality of piglets based on farmer's responses (150)	Overlay	31.33
	Hypothermia	12.67
	Diarrhoea	2.67
	Cannibalism	2.67
	Multiple causes	62.67
Disease complex observed in the farm based on syndrome (158)	Respiratory	6.33
	Enteric	8.86
	Skin/integument	46.84
	Musculo-skeletal	5.06
	Reproductive	12.66
	Others/mixed infections	39.87
Officials contacted in animal disease situation (162)	Veterinarians	20.37
	Animal health technicians	52.47
	Extension officers	17.28
	Cooperative department office	2.47
	Community leaders	0.62
	Others	14.81
Basic hygienic measures implemented on farms (161)	Hand wash	8.07
	Fence	65.84
	Foot bath	1.24
	Change of cloth	0.62
	Other measures	24.22
Vaccination of pigs (162)	No	98.77
	Yes	1.23
Medicine frequently used in the farm (158)	Penicillin	5.70
	Oxytetracyclines	30.38
	Ivermectin	22.15
	Sulpha medicines	1.27
	Others (Iron, vitamins, other antibiotics etc.)	56.33

A total of 52.47% of the ESSPF prefer to report to and use the service of (AHT). State Veterinarians are the first point of contact by one out of five farmers (20.37%) and 17.28% will prefer to contact the extension officers first. The knowledge and implementation of biosecurity is poor amongst the surveyed farmers as only 8.07% will wash hands and only 1.24% utilise footbaths in their farms. Although 65.84% indicated that they have built fences, it is noted that these fences were not purpose built for biosecurity but were only extensions of the human accommodations.

Most importantly, 98, 77% of the farmers do not vaccinate their breeding herd against major pig diseases including Parvovirus infection, Leptospirosis and Erysipelas. Oxytetracyclines (30.38%) were the most abused drug used by ESSPF since no diagnosis was reached before treatment was implemented in most cases.

The majority of the respondents (82.61%) will prefer to or are obligated to sell their pigs at local points and within communities and only 9.32% and 14.09% will sell at the auctions or formal abattoir/supermarkets respectively. A total of 40.67% of the farmers do transport the pigs to the slaughter facilities and only 1.33% of these farmers will transport live pigs from different sources in the same vehicle (Table 4).

Table 4 Market related characteristics of ESSPF in Limpopo, South Africa

Characteristics (number of respondents)	Variables	Percentages of respondents
Where pigs are sold? (161)	Abattoir	13.04
	Supermarket/butchery	1.86
	Auction	9.32
	Pension points/local markets	45.96
	Within communities and others	36.65
Source of transport to market (150)	Own	34.00
	Hired	5.33
	Shared	1.33
	Don't transport	59.33
Mean distance from farm to market (151)	<50km	20.00
	51-150km	18.71
	151-250km	7.10
	251-500km	3.87
	>500km	0.65
	Not applicable	49.68

The distance covered to go to Belfast auction may be as low as ≤50km but can be as far as ≤400km. The distance travelled to go to abattoir or slaughter points may be as low as ≤5km for local slaughter points, ≤150km for Phalaborwa abattoir, ≤200km for Thabazimbi abattoir but can be as far as ≤400km for Bronkhorspruit abattoir (Figure 4).

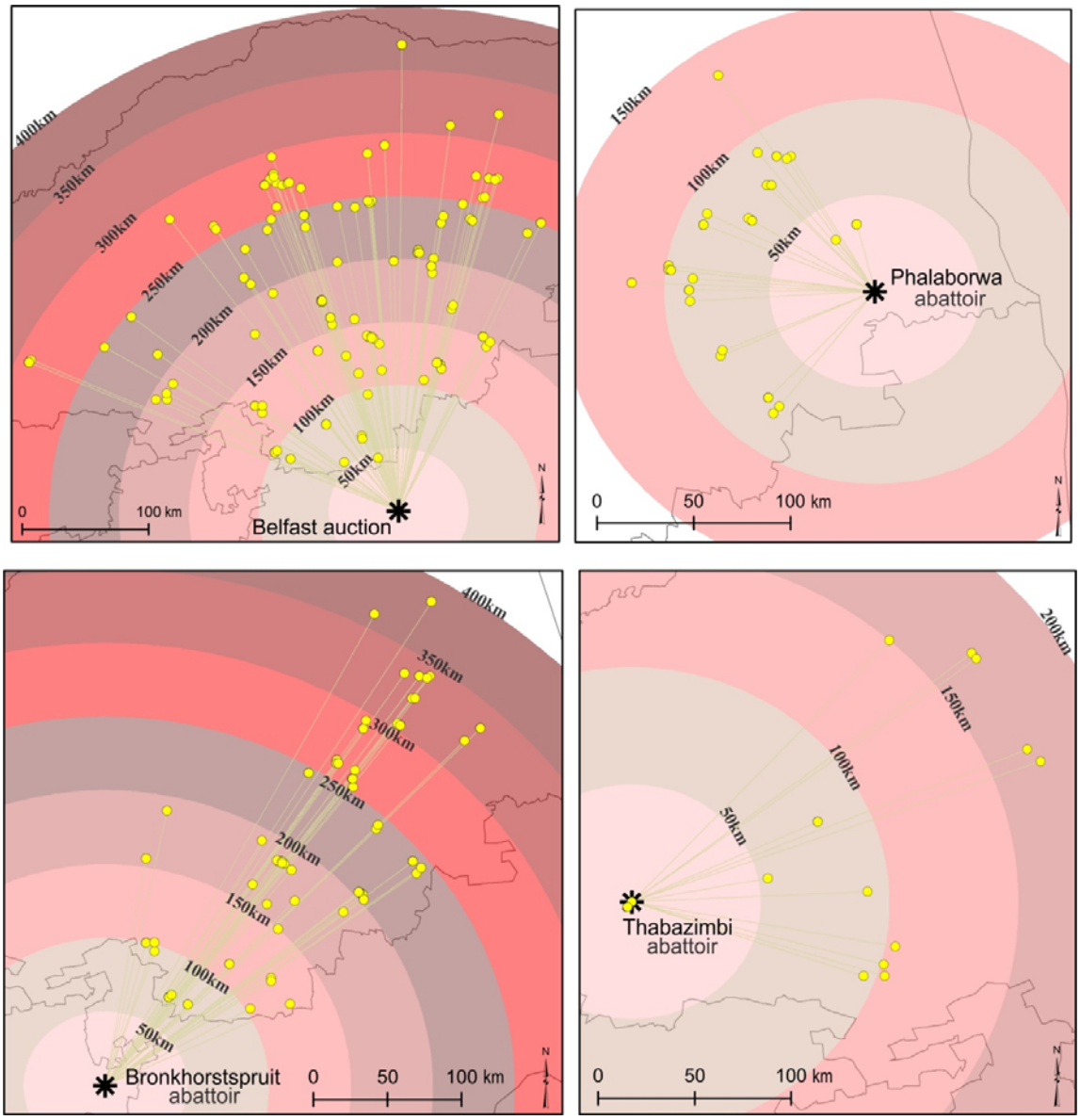

Figure 4: Distance analysis of movement from major slaughter and marketing points

An evaluation of the price the farmers received per pig sold revealed that there's a great lack of coordination in pricing and no template exist to standardize sales. For example, a 32 week old pig (50-70kg) sells for approximately R500.00 compared with about R1200.00 for a 20 week old pig (≈ 70kg) in a formal market. It should however be emphasised that these pigs often have high bone to meat ratio when compared with those originating from a commercial operation.

Although a good proportion (41.25%) of the farmers claimed to use concentrates in feeding their pigs, evidence based on checklist contradicted this assertion. It will appear that most of the farmers use kitchen remnants, while others mix concentrates and kitchen remnants (mixed portions) and only supplement with vegetables and concentrate feeds (Figure 5). A total of 43.83 % use borehole as source of water for their piggery but a proportion (32.10%) used village streams and other water sources like river (9.26%) and municipal water (6.78%) (Figure 5).

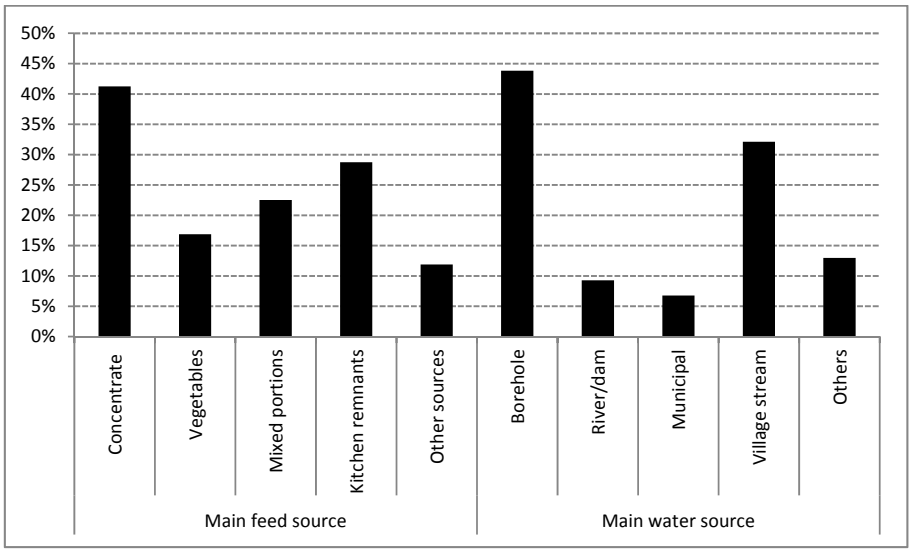

Figure 5: Main source of feed and water for the pigs

The majority of the farmers (81.76%) have less than 10 sows (Figure 6, Table 5) and this category of farmers appeared to have the best efficiency index compared to other categories in terms of number of piglets weaned per sow per year (5.19). It is shown that the higher the number of sows per ESSPF, the lesser the efficiency of weaning per individual sow in the farm (Table 5).

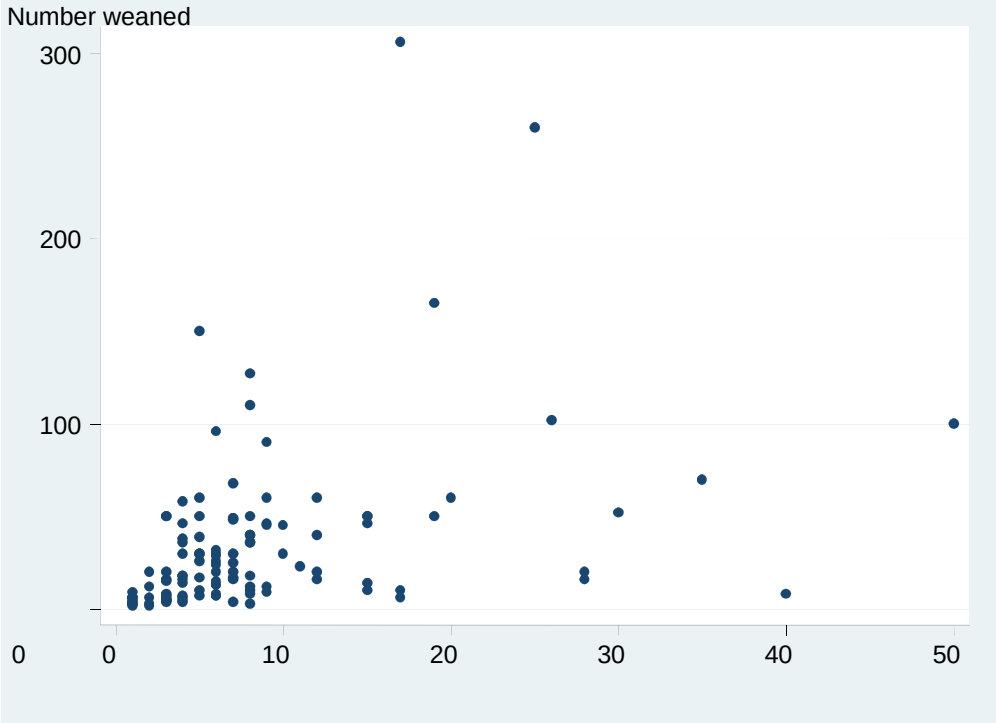

Figure 6: Evaluation of farm sow population against average number of piglet's weaned/sow/year

Table 5 Efficiency index of piglets weaned per sow

Sow number (frequency)	Mean number of sows/farm	Mean piglets weaned/year	Efficiency index of weaning/sow
1-10 (121)	5.12	26.59	5.19
11-20 (17)	15.46	60.2	3.89
21-30 (7)	27.4	90	3.28
31-40 (2)	37.5	39	1.04
41-50 (1)	50	100	2

The average number of days for sows to return to oestrus in the ESSP farms was 42.9 days (Table 6) but there was a significant difference amongst the different categories (1-10, 11-20, 21-30, 31-40, 41-50, P< 0.0001). Sows of those farmers with between 1-10 sows will take approximately 49.9 days to return to oestrus while those with between 21 and 30 sows will return on oestrus within 16 days (Table 6, Figure 7). However, some farms with less than 10 sows took up to 210 days for their sows to return on oestrus (Figure 7).

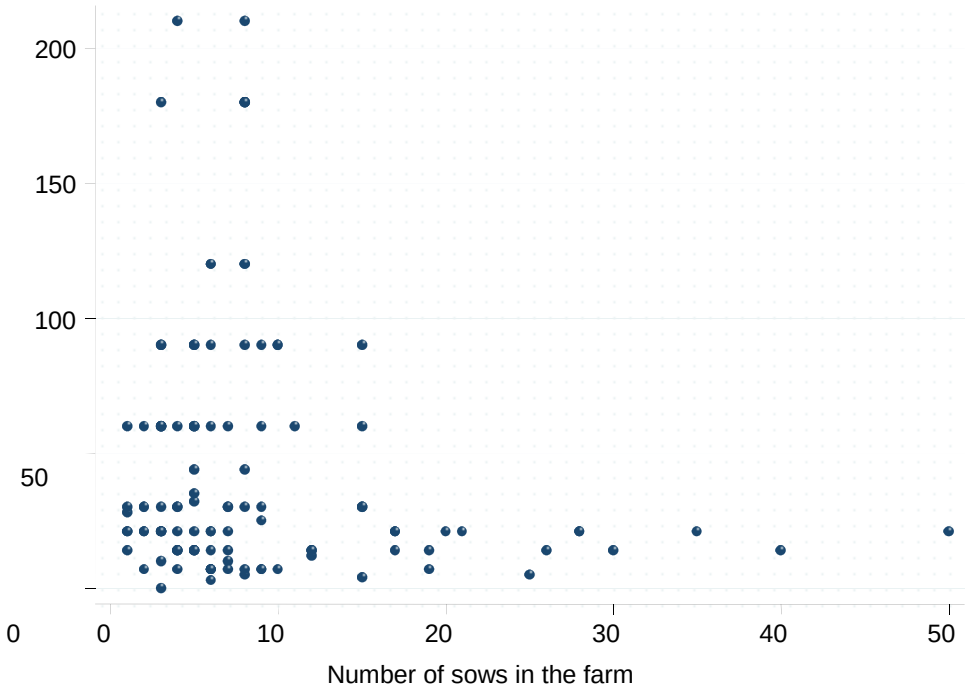

Figure 7: Evaluation of farm sow population against average number of days to return to oestrus

Table 6 Efficiency index of return to oestrus per sow

Sow number (frequency)	Mean number of days to return on oestrus/ sow ±SE (days)	95% Confidence interval (days)
1-10 (86)	49.9±5.4	38.4; 59.8
11-20 (15)	27.47±6.2	14.2; 40.8
21-30 (6)	16.0±2.6	9.30; 22.7
31-40 (2)	17.5±3.5	-27.0; 62.0
41-50 (1)	21	
Total	42.9±4.4	34.3; 51.6

Overall, the level of education was negatively correlated with all of the farm parameters assessed except the piglets per sow per year where it has a very poor correlation. The total piglets weaned was positively correlated with the total number of piglets born per sow per year (39.86%) and the number of sows in the farm was positively correlated with the total piglets weaned (30.97%) (Table 7).

Table 7 Correlation coefficient of sows with certain farm and farmer parameters

	Highest level of education	Breed of pigs	Number of sows	Days to oestrus	Piglet/ sow/year	Heat source present	Total piglets weaned
Highest level of education	1.0000						
Breed of pigs	-0.1929	1.0000					
Number of sows	-0.0560	0.1927	1.0000				
Days to oestrus	-0.1266	-0.0051	-0.1603	1.0000			
Piglet/sow/year	0.0006	0.1744	0.2112	-0.0911	1.0000		
Heat source present	-0.1760	0.1347	0.1981	0.0823	0.0696	1.0000	
Total piglets weaned	-0.0625	-0.0163	0.3097	-0.1418	0.3986	0.1851	1.0000

4.2 Spatio-temporal analyses of movement variables

4.2.1 ASF as model of risk factors during movement of pigs to market

One thousand, three hundred and nine (1309) cases of ASF were documented to date from 71 outbreaks in South Africa between 1993 and 2012 (DAFF 2014). This record presented in Table 8 is a summary of outbreaks recorded between 1993 and 2012 and excluded the historical outbreaks. Details of historical outbreaks can be obtained from Penrith (2013).

Table 8 Reported outbreaks of ASF 1903-2012 in South Africa

Timeline	Years	Province	Outbreaks	Cases	Dead/euthanized	References
Historical	1903-1939	Cape Town and the Transvaal (1903)*, Krugersdorp and Johannesburg (1901-03)*, Western Cape (1905, 1910, 1912, 1917, 1918), Transvaal, Pretoria and Krugersdorp (1904-06), Potgietersrus (1926-1930), Western Cape (1933-1936), Piquetberg* (1934-1939), North-eastern South Africa (1935).				De Kock, Robinson & Keppel (1940); Penrith & Vosloo 2009; Penrith (2013)
Recent	1993-2012	Limpopo	54 (76.1)	1040 (79.4)	1258 (64.1)	Evans 2012; Spencer 2012; Penrith, & Spencer 2014; DAFF 2014
		Mpumalanga	9 (12.7)	133 (10.2)	585 (29.8)	
		Gauteng	6 (8.4)	132 (10.1)	116 (5.9)	
		Kruger National Park	2 (2.8)	4 (0.3)	4 (0.2)	
		National	71	1309	1963	

*Cases may have been CSF or ASF. No clear distinction was established between the two diseases in earlier years. A comprehensive review has been produced by Penrith (2013)

A huge 76.1% of all outbreaks within the reviewed period originated from Limpopo while a large proportion of the other provincial outbreaks have links with the province (Table 8). Mpumalanga and Gauteng provinces only recorded outbreaks in late 2011/early 2012. A total of about 54 years of quiescence existed wherein no outbreaks were recorded (Table 8).

In addition, with regards to the districts under the province, no outbreaks were reported from Capricorn and Greater Sekhukhune, while all outbreaks in Limpopo were reported from Waterberg, Vhembe and Mopani districts. These three districts serve as interface locations between domestic and wildlife activities in the province or have links with international boundaries as seen in Table 9.

The results show that ESSPF are dispersed diffusely throughout Limpopo with a tendency for greater farm concentrations around Capricorn, Mopani and Greater Sekhukhune districts (Figure 3).

Table 9 Showing details of outbreaks originating from Limpopo between 1993 and 2012

S/no.	District	Preferred abattoir/slaughter point	Relative number of outbreaks originating from each district	Notes
1	Capricorn	Local	0	Religious forbiddance, local pig trade
2	Waterberg	Thabazimbi	19	Many wildlife conservancies/parks
3	Vhembe	Bronkhorstspruit, local	4	Boundaries with KNP
4	G. Sekhukhune	Bronkhorstspruit	0	Landlocked, External pig trade
5	Mopani	Phalaborwa	4	Boundaries with KNP
6	Kruger National Park[#]		2	Operate separately under the national government

Table was prepared based on outbreak data from 1993 to 2012. All index cases originate from small to medium scale farms. All data were retrieved from DAFF records (DAFF 2014). ESSP farmers from all the districts patronise the Belfast Auction in Mpumalanga. [#]KNP is not part of LP

The preferred abattoir for the ESSPF from Limpopo province is Bronkhorspruit (Gauteng) while 99.4% of the ESSPF will also preferentially choose Belfast Auction in Mpumalanga to source their pigs or sell whole animals. Other abattoirs mainly used are the Thabazimbi and Ba-Phalaborwa abattoirs. Importantly, some ESSPF especially from Capricorn district will prefer to slaughter pigs within the communities (Figures 8a&b).

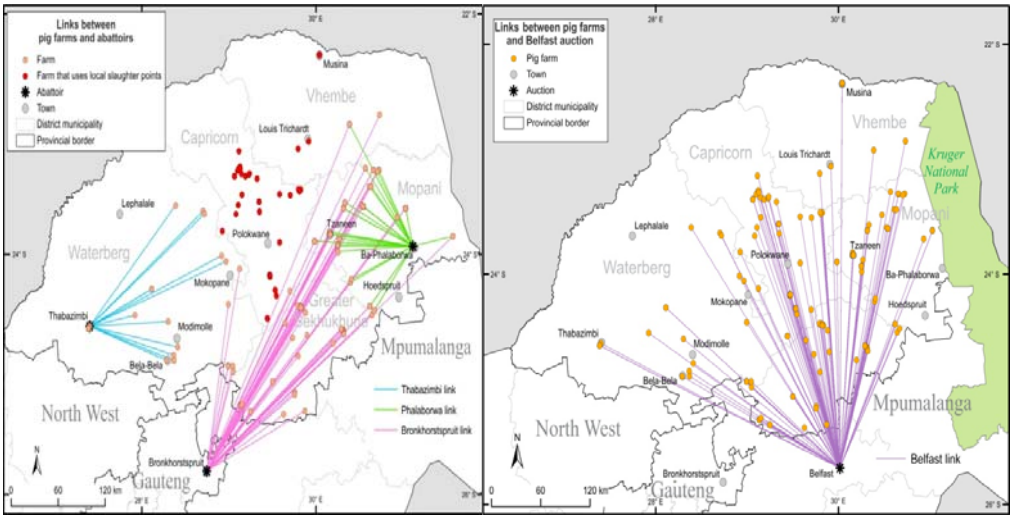

Figure 8: (a) Links between ESSPF and destinations of final products, (b) Links between ESSPF and their preferred auction points

However, no specific pattern exists with regards to the farm distributions or choice of slaughter/sale facility and the distances from the closest secondary or national road(s) to the farms (see Appendix 3 and Figure 9).

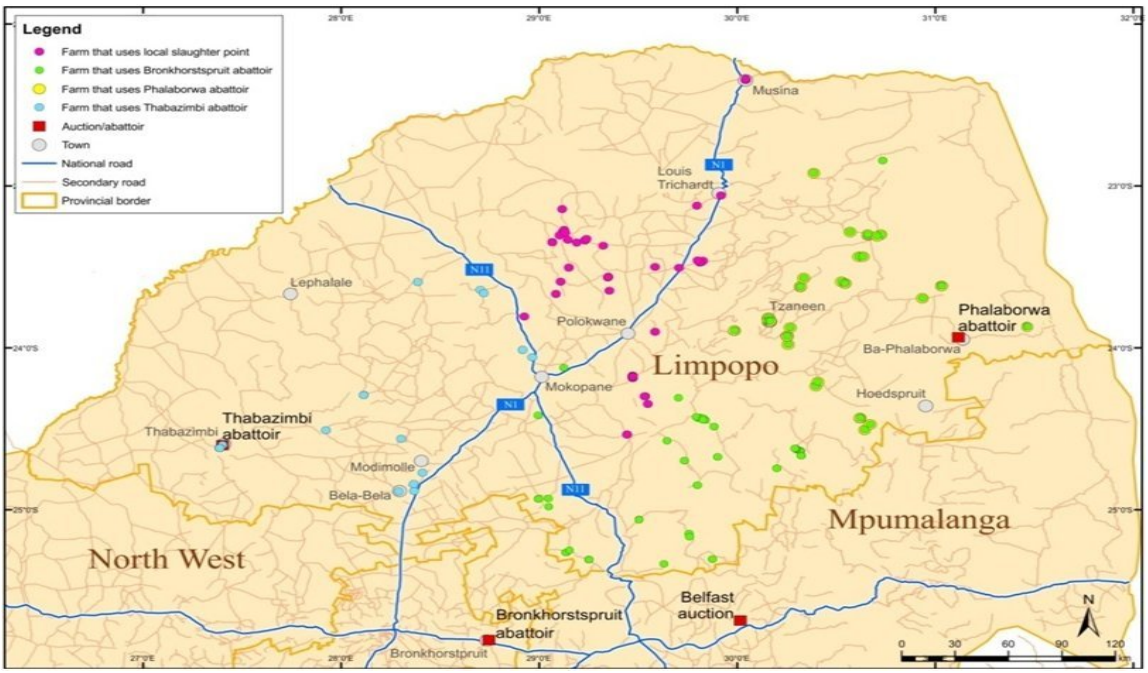

Figure 9: Distribution of location of surveyed farms based on preferred slaughter location/auction market and the national and secondary road networks

While relationships with wildlife parks, conservancies and sharing of borders with the Kruger National Park was associated with the risk of outbreaks, the slaughtering points (local, Phalaborwa, Bronkhorstpruit and Thabazimbi) appeared to have the greatest influences on further disease dispersal following potential outbreaks (Figures 8a&b, 10).

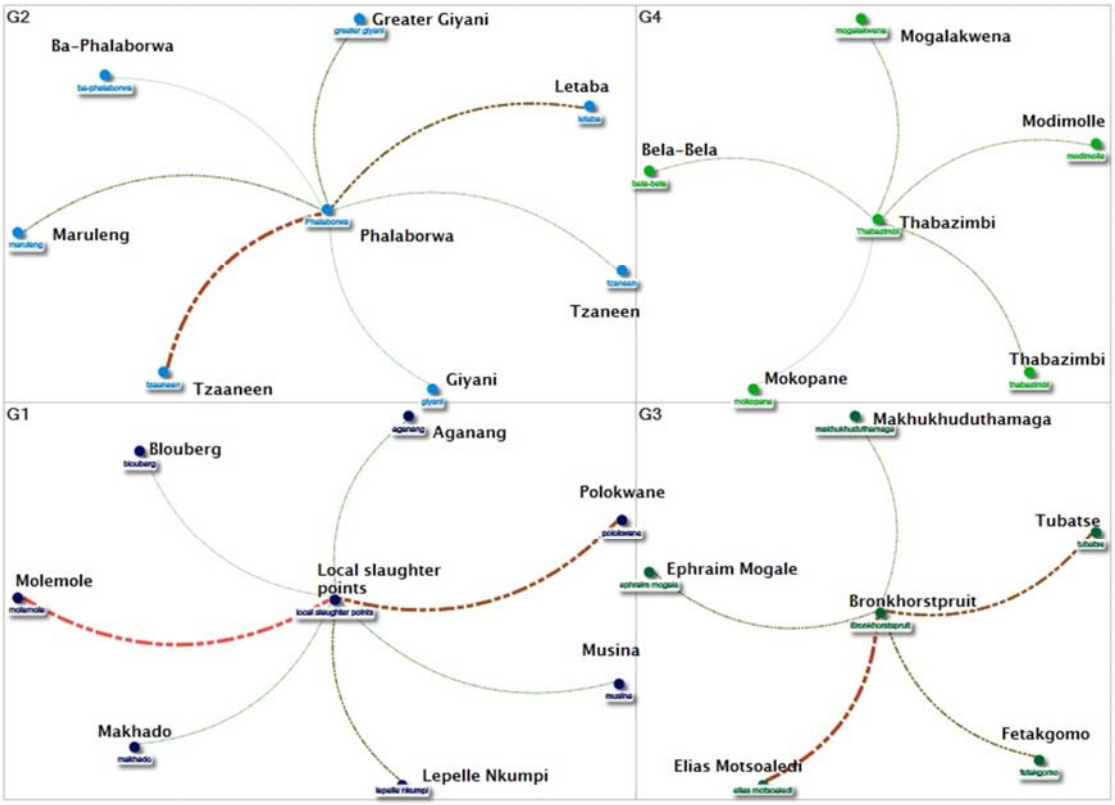

Figure10: Network map of connected locations for ESSPF in Limpopo province

The slaughtering points (local, Phalaborwa, Bronkhorstpruit and Thabazimbi) appeared to have the greatest influences on disease dispersal. Following infections through contacts networks, these points will rapidly serve to disperse new infections. The edge colours, edge widths and edge opacities are based on edge weight values. The vertex sizes are based on betweenness centrality values)

Overall, the graph has 28 vertices and 2 unique edges with total edges of 161. There were 4 connected components with an average geodesic distance of 1.48. The graph density had a value of 0.0634920634920635 and a modularity value of 0.143359 (Appendix 3). The top ten vertices ranked by between centrality were the local slaughter points, Phalaborwa, Thabazimbi, Bronkhorstspruit, but also Molemole, Ephraim Mogale, Letaba, Tzaaneen, Makhado and Blouberg (See Figure 10 & Appendix 3).

CHAPTER 5: DISCUSSIONS

5.1 Pig farm production systems constraints and challenges

5.1.1 Production system challenges or constraints evaluated

This work and analyses revealed some deficiencies with regards to record keeping. It becomes a difficult task to collect critical production parameters where no records exist to validate the collected information and the farmers' perception and recall were the only forms of validation. In this study, an effort was made to use check questions and interviewees' observational analyses to validate some of the collected data from the farmers. Despite this challenge, the study has revealed that most of the ESSPF in the province are males (77%), a fact that put to question the issue of women in agriculture and economic empowerment in this sector. It will appear that the pig industry is largely imbalanced in terms of ownership and gender, and there may be a need to transform this industry and provide more opportunities with critical focus on the rural women. It should be understood though that pig farming is labour intensive in terms of inputs and only few women are ready to be involved in such activities. While gender equity is one of the major standpoints of the land reform policies, to date, women ownership of land and other means of agricultural production, especially in the rural areas are still viewed with some degree of abhorrence (Cross & Hornby 2002; Kalabamu 2006; Anon 2014).

The majority of the farmers were older than 45 years of age, an indication that the younger generation prefer not to get involved in agriculture but will rather migrate to urban areas in search of salaried jobs. This observation may also be an indication of late entry into pig production and this is a challenge in terms of skill transfer from elderly to the youth. A similar trend has been observed in other studies (Oladele *et al*. 2013; Schembri *et al.* 2013). Currently, it is widely perceived that only the poor get involved in rural farming and it is not a financially rewarding activity. Policies that will encourage the younger individuals to be retained in the rural areas will need to be implemented at all levels to reduce gross emigration to the city while boosting agricultural productivity in the rural areas.

Since pig farming in the rural areas involves the service of many individuals, larger families and married persons are at advantage since two or more persons are involved. The outcome of our analysis indicated that 78% of all respondents were married. The majority of the farmers were also educated up to the end of high school (58.64%). Lubungu *et al.* (2012) confirmed that the level of education will have a positive relationship with market access. Since farmers with post-secondary education are just above a quarter of the total respondents, it is expected that these enlightened farmers will positively influence the market and open access for the less educated ones and based on the field observations, more enlightened farmers use their knowledge to practice the latest farming methods more easily than their counter parts. It is important to emphasise that the majority of the respondents still kept indigenous and crossbred pigs. These results are comparable with the data from India (70%) (Nath *et al.* 2013). These indigenous and undefined pigs have been known to underperform compared with the exotic breeds in terms of litter size, litter weight, birth weight, weaning weight and average daily weight gain; and they often enjoy poor veterinary services (Halimani *et al.* 2010). Veterinary extension services must be targeted towards encouraging farmers to adopt the improved breeds of pigs in rural farm operations.

Although LDA has made available certain provision for funding of livestock infrastructure in terms of CASP, only 2.47% of the respondents have benefited. It will be necessary for DAFF to fine tune its agricultural policies and remove unnecessary bottlenecks that impede the development of ESSPF in order that planned programmes and policies can reach the targeted beneficiaries. In the current programme, the farmers were supported in terms of provision of 10 sows or a housing unit for 10 - 50 sows. A realistic economic model has indicated that farmers need between 150 and 250 sows to be commercially viable. While the government may not be able to provide this level of support for all the ESSPF, the options of forming them into smaller cooperatives to benefit from economies of scale and become more competitive in terms of input supplies and marketing should be explored (Mashala 2012). Farmers should be encouraged to have specialised units like having breeding herds, selling weaners and other farmers having growing units selling porkers, this will encourage them to sell more pigs and also buy cheaper in bulk as a group.

It has been noted through observation that farmers supported by government had better infrastructure, facilities, and better or improved breeding stock. It is important to note that if these farmers were supported enough financially and properly mentored they will be able to produce optimally. Any form of government support should encourage sustainable prosperity other than that government will be creating dependent and unsustainable farmers. There should be a means to ensure that these farmers have a level of accountability to government. In addition, financial institutions should be encouraged to provide low-interest agricultural financing to farmers with viable projects.

With regards to productivity, the analysis indicated that the ESSPF are poorly productive compared with the commercial operations. They weaned an average of 4.85 pig/sow/year, a mere 19% of the standard for the South African pig industry (26 piglets/sow/year) and it took much longer for the sows to return on oestrus (42.9 days compared with 4-6 days) (Fasina 2012; Spencer 2014). The statistics generated in this study are incompatible with economically feasible and viable pig production and there will be need for a major shift if the ESSP farms are to be commercially viable and sustainable in South Africa. At the same time consideration is given to these statistics, it should also be carefully viewed since large variations exist between the farmer's operational efficiencies in each category.

Hypothermia is a major cause of neonatal piglet mortality and it predisposes piglets to other aggravating causes of mortalities including diseases, crushing and starvation (Kammersgaard *et al*. 2011; Pedersen *et al*. 2012). Hypothermia significantly reduces the ability of piglets to access the sow's udder and get colostrum within the first 6 - 12 hours after birth to meet their nutritional requirements in order to stimulate maternal immunity and protection against diseases. Though regular supervision in the farrowing house will help to reduce the levels of mortalities in terms of prevention of hypothermia, regular feeding, reducing illnesses and maintaining sow's udder health (Shankar, Madhusudhan & Harish 2009), such were basically lacking in the surveyed farms. The huge majority of the respondents (92.36%) did not provide a heat source for pre-weaning piglets and the high level of pre-weaning mortality observed in the farms of ESSPF in Limpopo can be attributed to this situation. Pedersen *et al*. (2012) has confirmed that mortality associated with hypothermia can be

seven times more severe in piglet subjected to suboptimal environmental and floor temperature in the first week of birth (Kammersgaard *et al.* 2011).

Pigs are exposed to a variety of predisposing factors and pathogens causing diseases. Primary diseases and conditions of concern in the industry include the production limiting diseases, respiratory complexes and lameness-associated problems amongst others (Mokoele *et al.* 2014; Spencer 2014). In this analysis, disease complexes were grouped as syndromes for ease of recognition by the ESSPF as they are non-professional and may not be able to identify specific disease pathologies. The disease conditions were grouped as respiratory, enteric, skin/integumentary, musculo-skeletal and reproductive syndromes. Over forty-six percent (46.84%) of the respondents indicated that a skin condition was a major challenge in their farms. Further enquiries from respondents confirmed that the conditions on pigs were observed as scratching, with discoloured or thickened skin, scabs and hair loss among others, an indication of sarcoptic mange (Turton 2001). Mange significantly depresses growth rate and feed efficiency and it is expected that a huge loss in days-to-market prevailed amongst the pigs from these farms due to the above reason. Many of the farmers sell their pigs at an average of eight months, a loss of about 90 days compared to commercial operations. Unfortunately, only 22.15% of the respondents mentioned ivermectin (macrocytic lactones) as a frequently used medicine in the farm.

It is particularly concerning that oxytetracyclines is used routinely by about 30% of the farmers most of the time without proper diagnosis and consideration for its proper use and consequences. Community-specific farm health plans will need to be made to target this group using state veterinary officials at their nearest state vet offices (Arends *et al.* 1990). Such health plans must include messages on importance of vaccination programme, proper use of antibiotics and biosecurity, areas where huge deficiencies were observed amongst the respondents (FAO. 2010; Fasina *et al.* 2012 a&b). Vaccination of the breeding herd against very important production limiting diseases in South Africa (Parvovirus, Leptospirosis and Erysipelosis, as well as *E.coli*) must necessarily be included in such a protocol (Mokoele *et al.* 2014).

Since the farmers will prefer to use the services of state veterinary officials and local agricultural extension officials, there will be a need for coordination of efforts among these professionals to maximise the impact of state veterinary extension services and block loopholes that may exist with individual efforts. Data comparable to our statistics, more reliance on animal health technicians rather than the veterinarians by ESSPF has been reported elsewhere (Alawneh *et al*. 2014). It should be emphasised that disease complexes among the ESSP farms pose huge risks to the commercial operations, and therefore the inclusion of private veterinarians and large commercial farms in sponsoring veterinary extension services amongst these individuals while serving the role of mentors and patrons must be critically evaluated (Hernández-Jover *et al.* 2012; Wilk *et al.* 2013). The extension messages must also target how market access can be created for these farmers as well as a suitable grading system that will encourage them to maximise productivity and move towards good farming practices. The role of veterinary extension and the usage of multiple professionals to meet the challenges of animal health services have been emphasised previously (Turton 1999; Hernández-Jover *et al.* 2012; Mockshell *et al*. 2014). The determinants of cooperation and referrals between para-professionals and veterinarians have been previously identified to include mobile phone ownership, training, cumulative annual assessment and membership of para-professional bodies and association among others (Ilukor *et al.* 2014). It will therefore become necessary to facilitate inter-professional relationship amongst animal health service providers in rural South Africa by provision of the identified facilities.

Nutrition and feeding are very important components of animal production and health; in this study, it is been established that the ESSPF are more likely to swill-feed the pigs with potential consequence of spread of exotic pig diseases like Classical Swine Fever (CSF) and Porcine Reproductive and Respiratory Syndrome (PRRS) (Penrith *et al.* 2011). Similarly, since the various swills are not evaluated for their nutritional qualities, it becomes difficult to assess whether this feed will meet the nutritional requirement of the different classes of pigs in the farm. It is probable that the weaners and grower pigs were underfed and this was the main reason why they took longer to reach appropriate market weights, and it is also possible that they had conditions such as gastric ulcers and other related diseases (Carrington 2004; Manchidi 2009). It is also probable that sows that are fed swill will also

contribute to poor performance in terms of taking longer to return to oestrus and weaning less piglets/sow/year (Mokoele *et al.* 2014).

Water is a critical resource in any pig production unit, as it is required for cleaning the pens, drinking purposes and cooling of the pigs (Carrington 2004; Manchidi 2009). In many of the farm units included in this study, pigs received water only twice a day, while certain piggeries only supplied water every other day. Limited access to water has negative effects on the pig as it retards their growth potential and affects many other biochemical processes resulting in conditions such as salt toxicity (Manchidi 2009). The greater the distance between the household / production site and water source, the higher the probability of not serving water regularly based on our estimation. Since about 45.06% of the farmers depend on village streams or other distant sources for water, pigs reared under these conditions are likely to suffer degrees of water deprivations. However, if a farmer will want to proceed with regular supply of feed and water despite the distance between the farm and sources of supplies, a higher capital cost will be incurred and realistic profitable operation will become more difficult (Mabuza & Ngubane 2010).

Indeed, the South Africa pig industry is broadly classified into a dual market structure: the high-value markets (processors and supermarkets) for commercial pig farmers and the low-value markets (local auctions, pension point sales for the ESSPF). While the high-value markets pay premium price for quality products, the ESSPF get paid below the market values for their pigs (Antwi & Seahlodi 2011). Study findings confirmed this assertion since no coordinated pricing and standardized sale template exists for this category of farmers. The use of extension services to improve sectoral marketing and possible formation into cooperatives will be critical.

5.2 Spatio-temporal analyses of movement variables

5.2.1 ASF as model of risk factors during movement of pigs to market

The results revealed interesting and important insights into the outbreak of pig diseases in South Africa. Using ASF as a model, approximately 76.1% of all outbreaks originated from Limpopo with direct links to another 21.1% of other outbreaks from Mpumalanga and Gauteng. As seen in the 2012 ASF outbreak in Sundra (Mpumalanga) and the ASF spilling over to Gauteng (Spencer 2012; Penrith *et al* 2014).This is indicative of the role that Limpopo as an important disease node for pig diseases and it remains a huge vertex for national dispersal of infections thus it should demand utmost attention. Due to economic reasons, farmers will preferably market their pigs in Bronkhorstspruit abattoir and the auction in Belfast (locations that were almost 400km away from certain farms); the potential long distant spread of infection becomes real in an outbreak situation. These should particularly appeal to national and provincial veterinary authorities to prioritize and refocus surveillance and diagnostic efforts in the province with the aim of ensuring early disease detection and implementation of control and eradication methods. It should be noted that movement control policy exist and is maintained in South Africa but emergency situations often challenge such policies.

There is a need for standing local emergency response teams in Limpopo that can readily conduct active surveillance and do participatory epidemiology amongst the ESSPF. Since it will appear that economic values of final products and not the distance to the nearest abattoir are the main drivers for movement of pigs (see figure 8a & b, and 9 above), it would be worthwhile to create suitable abattoirs and meat processing facilities within a 100km radius of every district in Limpopo. This will reduce the risk of distant spread of infection should there be an outbreak and aid in rapid disease control within a single province. It will also become advantageous as the profit margins for farmer will increase by reducing the cost of transportation. Motivation for good farming practice amongst the ESSPF may be enhanced by the offer of valued pricing for pigs produced under an improved management and biosecurity measure and certificated by the local veterinarians in such abattoirs as well

as government support system to enhance their operations (Fasina *et al.* 2010; Fasina *et al* 2012b; Logar 2014).

With regards to the districts under the province, certain patterns became evident; Waterberg district have a total of 19/27 outbreaks (70.1%) reported from Limpopo. Since the district is rich in private wildlife farms and conservation areas, it is expected that more domestic animal-wildlife interactions will exist and the tick host of the ASF virus, *Ornithodoros moubata porcinus* may be present in abundance in the district (Arnot *et al.* 2009). There will be a need to do careful survey(s) of the district to confirm or disprove this hypothesis as well as a need to maintain strict movement control and ensure double fencing for all pig farms located within the district. Lephalale municipality contributed the majority of the outbreaks in the district and historically this same municipality have made major contributions to pig disease outbreaks in South Africa since the late 1920s. Another major contributor to outbreaks is the Thabazimbi municipality (a major abattoir location).

Similarly, Musina municipality in Vhembe district as well as Phalaborwa (a town with an abattoir) in Mopani district both contributed 75% of outbreaks arising from each districts. Both locations share borders with the Kruger National Park. While ensuring continued monitoring and effective surveillance in these locations, it will be critical to re-evaluate the role of the wildlife-domestic animal interphase and its contribution to disease dynamics within the border towns (Arnot *et al.* 2009).

Interestingly, no outbreak was reported from Capricorn and Greater Sekhukhune. In Capricorn, local slaughter predominates and religious activities that shift preference away from pork are keenly practised. This may have had some inadvertent degree of influence on the control and circulation of pork products within the district with a consequent positive outcome on disease control. The majority of the farmers within the district prefer local slaughter and the fact that they can source a market in Polokwane, a major city within the district, obviate the need to travel the long distances to other provinces. This becomes beneficial in limiting the geographic dispersal of rapidly spreading transboundary animal disease outbreaks since pork distribution is localised. Both Capricorn and Greater Sekhukhune districts are also landlocked districts away from the parks and potentially they

may benefit from some degree of freedom from tick hosts and wildlife-domestic animal interactions. However, should there be an outbreak; potential local spread is a real possibility for these districts.

The movement of pigs between farms and social interactions between contact networks associated with pig farms are important factors in the transmission of infectious diseases (Kao *et al.* 2007). This model has identified local slaughtering points and other abattoirs as potential points with the greatest influence on disease dispersal. Strict anticipatory planning should be implemented for these locations and supervised slaughtering should be encouraged (Kao *et al.* 2007; Lindström *et al.* 2010).

CHAPTER 6: SUMMARY AND FUTURE RESEARCH

The Limpopo province is an important pig production area in terms of animal population compared to other provinces and its involvement to transboundary animal diseases. It also plays an important role in diseases associated with the domestic animal, human and wildlife interface. Emerging Small-Scale Pig Farmers in this province perceived pig production and management as an important means of improving their livelihood and also as an alternative investment option for the future. However, for these farmers to perform optimally, they need to understand the basics of animal production, biosecurity and efficient production. In this study, some factors that limit improvement in the efficiency of small-scale pig farmers have been identified and these include a lack of, or inadequate relevant pig farming knowledge, finance and also a lack of proper records. Without records, it is difficult to collect and evaluate critical production parameters and critically evaluate the financial health of the farm.

Men dominate the pig farming activities in the province, while women and the youth are under-represented. Rural women are still faced with severe constraints in terms of access to productive resources e.g access to land and funding. It is important for LDA to have a strategy in place to alleviate constraints faced by women, as they make important contributions to the livestock production and rural economies of this country. At the moment, more research is still needed to determine the level and the nature the contribution made by women. Empowerment of women in animal production still needs to be evaluated and put high on government implementation agenda.

The youth prefer to look for salaried jobs in the urban areas. As we know South Africa at large has more young people that are un-employed, the intervention geared on helping young people to farm effectively and profitably is encouraged, this will reduce youth unemployment rate and also promotes rural development. Generational mix will ensure coaching and mentoring by the older generation. Pig farming should be made fashionable to be able to attract the youth, formation of youth cooperatives is imperative. The initiatives like young female farmer awards as are reportedly implemented in the province should be a model of success. Most of the farmers are married and are involved in farming activities as a

family; this is a very good model as pig production is very labour intensive. This has the ability to encourage mentoring of the youth by family members involved in pig farming. It is always better to be involved fulltime in farming, in that way monitoring and evaluation is ensured. Generally most farmers are involved in more than one farming commodity but this has a negative result as some commodities will suffer neglects and fail to perform efficiently.

In the study, the majority of the farmers' uses indigenous breeds, although these are tolerant to the local environment, they are known to have difficulties in terms of reaching production targets. The use exotic breeds are encouraged, there is literature to prove their ability to reproduce and produce better although the cost of acquiring these breeds is a drawback to most of emerging farmers. More research work is needed to evaluate the production parameters of the indigenous breeds in South Africa.

Pigs need a proper housing infrastructure and facilities like proper farrowing crates and heating facilities for the piglets without compromising the micro-environment of the sow. It is shown that the farrowing crate primarily reduces preweaning mortality by reducing the sows' ability to lie down quickly thereby crushing the piglets. Pig housing facilities is the biggest expenditure of the whole operation and most of the time serves as a deterrent for the farmers to start farming. The 2.47% of farmers that had received help from government through CASP don't have challenges with regards to facilities because their facilities are of a high standard. CASP has also addressed production inputs in terms of acquiring exotic breeds and some basic veterinary medicines for the supported units. The farmers who received help need to be seen as a success model for the other pig farmers, being independent and sustainable. However, the percentage of farmers that received support is very small. It is recommended that good programmes like this be encouraged to reach more committed farmers in the rural areas. The selection model also needs to be transparent and address the needs of the farmers who have already started with their farming operation.

Good husbandry is central to improved production and profitability as most of the farmers had between 1-10 sows producing 4.8 litters/sow/year. Most of the farmers deliberately reduced their sow numbers due to challenges related to acquiring feed in terms of their

inability to afford commercial feed. The rural pig farmers need to start taking responsibility for their farming business ventures to ensure that it thrives despite all known difficulties. They need to start putting basics together like proper biosecurity measures, vaccination of their breeding stock against major reproductive diseases and reporting diseases to their nearest State veterinary offices in their district municipalities. The veterinarians play an important role in advising on issues of pig herd health, production and management.

Knowledge has been identified as one of the essential factors causing ESSPF to underperform and therefore a well-coordinated veterinary extension service is of paramount importance to the success of these farmers. The veterinary services should prioritise pig farm production by having a plan and strategies in place to ensure that veterinarians and para-veterinarians are a part of a strategy to grow farmers and also help reduce the impact of pig diseases. Adoption of this key result area should be measurable and also evaluated all the time.

Resources in terms of transport and equipped personnel need to be channelled to this purpose and the veterinary officials need regular specialised training on pig production to be able to deliver a quality veterinary extension service. This involvement and participation of veterinary officials will help to reduce the outbreaks of transboundary diseases which threaten food security, food safety, and mostly affect the livelihood of rural communities with a more damaging effect on local and international trade. The outbreak of transboundary diseases threaten the pig industry and can cause huge economic losses to both producers and the economy.

The veterinary officials should share practical knowledge and train farmers to raise their pigs successfully and to apply simple processing techniques to produce various pork products. This increases the value of the commodity and enables small-scale farmers to sell pig products within a reasonable time. They also need to transfer knowledge on how to reduce pre-weaning mortalities that is associated with crushing and chilling and also encourage provision of heating facilities to allow piglets to use their energy to grow rather than using energy to heat up their bodies.

Feeding of kitchen remnants from hospitals, schools and public gathering is an issue of concern and calls for research on how best rural pigs could be fed within minimum costs and also ensuring that basic nutrient requirements are met. This kind of feed is assumed to have a negative effect on reproduction and production targets of the piggery, and also can predispose pigs to exotic diseases like ASF and PRRS. South African regulations stipulates that all swill feed needs to be adequately heat treated but experience has shown that this is not done, hence the risk of spreading diseases.

A lack of pricing models is still a concern as this is tantamount to manipulation, and economic inefficiency. These farmers need to travel long distances to transport their pigs, increasing their transport costs but also reducing their profit margins. Those farmers failing to sell pigs at abattoirs and auctions resort to local pension points, with some allowing buyers to come collect pigs on their properties, consequently predisposing them to biosecurity and theft risk. Prices depend on age or size, time or situation of the farmer and this means small-scale pig farmers have little say on the price of their product, basically being price takers. Based on the above information, government and industry are urged to help facilitate creation of pig slaughter facilities within the province as this will be an aid to reduce transport costs and also encourage the farmers participation in the pig industry, dealing with the triple challenges of poverty, unemployment and inequality. It will be advisable to have affordable slaughter facilities within a 100km radius of the districts or major towns to cater for the needs of ESSPF in Limpopo. These will assist in the slaughter of other species as well.

The veterinary services in the province, South African Pork Producers Organisation (SAPPO), the industry, teaching and research institutions need to engage each other on how to train, mentor, coach and support ESSPF in the province, with the aim of improving their livelihood, food security and safety. This dream of ensuring that emerging farmers become commercially viable is attainable through unity, moral responsibility and scientific research.

CHAPTER 7: REFERENCES

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CHAPTER 8: LIST OF APPENDECISES

8.1 Appendix 1: Consent form and questionnaire

100
1908 - 2008

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

An investigation into the reasons resulting in poor production among the ESSPF of the Limpopo Province of the Republic of South Africa

The University of Pretoria, Faculty of Veterinary Science is conducting an investigation into the reasons resulting in poor production among the ESSPF of the Limpopo province of the RSA.

You have been selected as one of our respondent to kindly answer the questions with your consent and personal experience. The answers provided will be kept strictly confidential and will be used for research and planning purposes. No personal details will be revealed.

Thank you for your cooperation.

Name and surname …….

Signature …….

Date ……..

A. **Personal Information**

1. Name and surname.....
2. Gender □ M □ F
3. Age category

   A □ < 25 Years B □ 25 - 35 Years C □ 35 - 45 Years D □ 45 - 55 Years

   E □ 55-65 Years F □ Other (specify).....
4. Marital status □ Single □ Married □ Divorced □ Widow
5. District municipality.....
6. Local municipality.....
7. Farm name.....
8. Farm geographic location and coordinates.....
9. Do you own this land that you use for farming?

   A □ Own land B □ Lease C □ Communal D □ Other (specify).....

   .....
10. What is your level of participation in pig farming?

    A □ Full-time pig farmer B □ Part time pig farmer C □ Other (specify)

    .....
11. Do you have other people involved in farming?

    A □ Son B □ Daughter C □ Family D □ Cooperative E □ Employees

    F □ Other (specify) .....
12. What is your highest level of education?

    A □ Primary school B □ High school C □ Matric D □ Graduate

    E □ Other (specify) .....

B. Management or Production

1. What kind of pigs do you have in your farm?A □ Duroc B □ Landrace C □ Large White D □ Other (specify) ……
2. How many sows do you have in your farm? ……
3. What is the average number of days taken for the sows to return to heat after weaning?

   ……
4. How do you know that the sows are ready for mating? ……
5. How many boars do you have in your farm? ……
6. How many female pigs did you replace in 2012? ……
7. What is the average number of piglets born per sow per year in 2012?

   ……
8. What is the average number of piglets born dead in 2012? ……
9. What is the average number of piglets that died before weaning in 2012?

   ……
10. Why did these piglets die before weaning?

    A □ Laid on B □ Coldness C □ Diarrhoea D □ Dog eat them E □ Other (specify) ……
11. Do you have a heat source for your piglets □ Yes □ No
12. If yes, how do you keep the piglets warm? A □ Infra - red lamps B □ Heaters C □ fire or coal D □ Other (specify) ……
13. What is the average number of piglets weaned in 2012? ……
14. What is the average number of pigs did you sell, slaughter or give away in 2012?

    ……

C. Health plan

1. Indicate disease complex experienced in your farm?

   A □ Respiratory diseases complex B □ Enteric diseases or diarrhea C □ Skin diseases D □ Lameness or muscular problems E □ Reproductive disease F □ Other (specify) ……

2. Who do you contact in case of disease complex in your farm?

   A □ Veterinarian B □ Animal Health Technician C □ Extension officers

   D □ Cooperation E □ community leaders F □ Other (specify)……

3. What are the biosecurity measures that you have in your farm presently?

   A □ Hand-washing B □ Fence C □ Footbath D □ Change

   overalls E □ Other (specify) ……..

4. Do you vaccinate your pigs? A □ Yes B □ No

5. If yes, which vaccines do you use in your farm? ……..

6. What medicine do you use to treat diseases in your farm?

   A □ Penicillin B □ Teramycin C □ Ivermectin D □ Sulpha-drugs

   E □ Other (specify)……

D. Housing

1. Did you receive any financial help to build these pig houses?

   A □ Yes B □ No

2. If yes, what kind of help did you receive? ……

3. How many farrowing pens do have in your farm? ……

4. How many pens do you have for the boars? ……

5. How many pens do you have for the weaners? ……

6. How many pens do you have for the growers? ……

E. Feeding strategies

1. What type of feed do you feed your pigs?

   A □ Bought feed B □ Vegetables C □ Mixed (Dry meal and Kitchen food) D □ Kitchen food E □ Other (specify) ……

2. Where do you buy your feed? ……

3. What is the average amount of feed in Kilograms do you feed or give your pigs every day?

   3.1 Sows……

   3.2 Boars ……

   3.3 Weaners……

   3.4 Growers……

4. Where do you get water for the pigs?

   A □ Own borehole B □ River or dam C □ Municipality water D □ Village water E □ Other (specify) ……

F. Marketing strategy

1. Where did you sell the pigs in 2012?

   A □ Abattoir B □ Supermarket or Butchery C □ Auctions D □ Pension points or local- market E □ other (specify) ……..…..

2. How many pigs did you sell in 2012? ……..

3. At which average age did you sell your pigs in 2012? ……

4. What was the average cost per pig at the market?

   A □ R200-R300 B □ R300-R500 C □ R500-R800 D□ R800-R1200

   E □ Other (specify) ……

5. How did you transport your pigs to the market? ……..

   A □ Own transport B □ Hired transport C □ Shared transport

   D □ Other (specify) ……..

6. What is the distance between your piggery and the market?

   A □ Less than 50 KM B □ 50-150 KM C □ 150-250 KM D □ 250-500KM

   E □ >500 KM F □ Other (specify) ……..

7. What was the average market transport cost in 2012? ……..

Thank you for taking your time to fill this questionnaire. We rely on your feedback to help us identify the challenges of ESSPF.

8.2 Appendix 2: Distance to slaughter

Distance to nearest road from farms that use local slaughter points			local sl Sec	local sl natl
Farm number	Distance to nearest secondary road (m)	Distance to nearest national road (m)	67.67873	747.5419
2	67.678733	747.541916	629.4748	27284.16
5	629.474811	27284.16014	629.4748	27284.16
6	629.474811	27284.16014	814.7498	65702.15
15	814.749761	65702.14697	297.1282	9029.567
16	297.128215	9029.566705	862.6653	10896.09
25	862.665331	10896.09152	90.83715	40827.07
34	90.837154	40827.06681	6686.614	42148.32
35	6686.613834	42148.32094	90.83715	40827.07
36	90.837154	40827.06681	90.83715	40827.07
37	90.837154	40827.06681	6686.614	42148.32
39	6686.613834	42148.32094	6433.862	47274.59
40	6433.86201	47274.58987	6686.614	42148.32
41	6686.613834	42148.32094	3337.219	49779.79
48	3337.218713	49779.7898	4202.412	13649
49	4202.411605	13649.00256	2080.675	193.4174
52	2080.674934	193.417395	2080.675	193.4174
53	2080.674934	193.417395	67.69784	747.5316
54	67.697837	747.531597	4113.198	26097.44
66	4113.198022	26097.43876	1997.752	32301.71
67	1997.7519	32301.7088	2183.798	32239.39
69	2183.798408	32239.39371	1942.612	32425.06
70	1942.612273	32425.05527	2541.131	51636.09
74	2541.131155	51636.08994	416.3275	47500.08
75	416.32748	47500.08018	158.9503	56286.21
76	158.95026	56286.21351	158.9503	56286.21
77	158.95026	56286.21351	46.2614	52413.42
107	46.261395	52413.4176	1421.892	49271.7
108	1421.892149	49271.69661	147.1012	8888.587
109	147.101226	8888.58678	1456.753	57627.29
110	1456.752929	57627.28974	344.6611	9169.09
111	344.661093	9169.089983	175.2439	1317.889
112	175.243938	1317.888629	128.5551	9825.19
113	128.555131	9825.190457	697.7921	8547.521
114	697.792099	8547.520812	1361.727	6800.862
115	1361.727184	6800.861752	796.2758	670.6384
130	796.27575	670.638374	793.3888	13664.99
142	793.388789	13664.98985	1376.012	25805.3
143	1376.011759	25805.2955	1454.841	26273.17
144	1454.841259	26273.16507	1371.02	26530.44
145	1371.020331	26530.4373	1291.479	26242.28

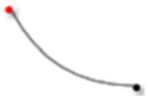
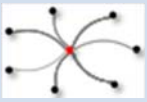
146	1291.478745	26242.27697	1633.003	25872.72	
147	1633.003489	25872.71817	629.4748	27284.16	
148	629.474811	27284.16014	479.0285	54339.86	
149	479.028491	54339.85879	305.6447	52835.13	
150	305.644676	52835.13188	422.105	42394.43	
151	422.105048	42394.42897	4109.656	36978.92	
152	4109.656363	36978.92282	4639.029	23267.04	
153	4639.028973	23267.03777	4292.259	3829.481	
155	4292.259208	3829.480833	777.7755	28521.69	
156	777.775506	28521.68773	422.105	42394.43	
157	422.105048	42394.42897	422.105	42394.43	
158	422.105048	42394.42897	422.105	42394.43	
159	422.105048	42394.42897	1242.438	26670.24	
160	1242.438396	26670.24328	1316.974	26283.17	
161	1316.974256	26283.16919	1624.1	29727.06	m
			1.6241	29.72706	km
Distance to nearest road from farms that use Bronkhorstspruit abattoir					
Farm number	Distance to nearest secondary road (m)	Distance to nearest national road (m)	5449.517	74903.97	
1	5449.517077	74903.97067	78.89617	37884.89	
3	78.89617	37884.89158	1132.952	37605.4	
4	1132.95248	37605.39598	3531.045	17232.44	
17	3531.045028	17232.43711	887.4898	27051.16	
18	887.489836	27051.1608	654.5293	13120.28	
19	654.52933	13120.27582	887.4898	27051.16	
20	887.489836	27051.1608	887.4898	27051.16	
21	887.489836	27051.1608	887.4898	27051.16	
22	887.489836	27051.1608	774.8494	26340.81	
23	774.849381	26340.80756	654.5293	13120.28	
24	654.52933	13120.27582	813.006	63920.85	
26	813.006037	63920.8542	3838.499	51572.27	
27	3838.498671	51572.26598	6712.298	143930.4	
28	6712.297956	143930.4173	77.79852	79885.12	
29	77.798522	79885.11566	6712.298	143930.4	
30	6712.297956	143930.4173	6712.298	143930.4	
31	6712.297956	143930.4173	241.0462	90088.97	
32	241.04618	90088.96689	75.05403	90075.37	
33	75.05403	90075.36586	871.7607	20539.67	
38	871.760684	20539.66583	492.384	75310.44	
42	492.383983	75310.43522	470.2078	53550.33	
43	470.207821	53550.33057	1579.57	75130.89	
44	1579.569732	75130.88973	133.1456	22767.43	
45	133.145624	22767.4275	108.0866	137282.9	
46	108.086636	137282.9032	871.7607	20539.67	
47	871.760684	20539.66583	35.42302	13695.52	
50	35.423023	13695.52125	35.42302	13695.52	

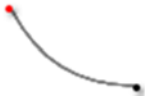
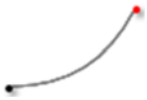
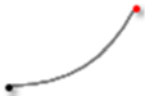
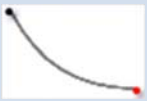
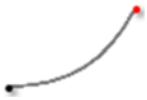
51	35.423023	13695.52125	2207.149	109392.2
55	2207.148956	109392.231	2207.149	109392.2
56	2207.148956	109392.231	2207.149	109392.2
57	2207.148956	109392.231	2207.149	109392.2
58	2207.148956	109392.231	148.4575	85965.09
59	148.457464	85965.09218	492.384	75310.44
60	492.383983	75310.43522	2914.968	2676.227
61	2914.968318	2676.227371	378.9652	78958.46
62	378.965247	78958.45825	702.9361	73653.42
63	702.936076	73653.41551	79.19299	76876.95
64	79.192989	76876.94571	1171.922	77759.98
65	1171.921703	77759.97547	2680.629	3101.28
68	2680.629264	3101.280283	871.7607	20539.67
71	871.760684	20539.66583	1544.225	14949.83
72	1544.225338	14949.82871	8604.836	90712.11
73	8604.836499	90712.10814	823.4069	201289.1
78	823.406879	201289.1182	338.5437	69279.51
79	338.543738	69279.51359	338.5437	69279.51
80	338.543738	69279.51359	338.5437	69279.51
81	338.543738	69279.51359	3419.771	67966.61
82	3419.771036	67966.61492	1743.326	62785.08
83	1743.326129	62785.08162	6026.68	93156.67
84	6026.680328	93156.66835	220.4716	77607.47
85	220.471604	77607.46808	1743.326	62785.08
86	1743.326129	62785.08162	13492.46	115188.3
87	13492.45759	115188.3014	9007.328	124461.8
88	9007.328418	124461.832	13961.58	118950.8
89	13961.58379	118950.8248	9007.328	124461.8
91	9007.328418	124461.832	3518.888	49919.45
92	3518.88802	49919.44592	3518.888	49919.45
93	3518.88802	49919.44592	8188.648	82741.87
94	8188.648077	82741.874	669.6519	64063.11
95	669.651918	64063.10818	9007.328	124461.8
96	9007.328418	124461.832	4257.124	112453.7
97	4257.124499	112453.6849	1201.065	111592.5
98	1201.065313	111592.5454	1660.72	97092.12
99	1660.719902	97092.11647	358.1994	95598.16
100	358.199354	95598.16101	2876.103	48839.11
101	2876.10334	48839.11353	4120.3	105887.4
102	4120.300442	105887.3649	2010.727	100184.9
103	2010.726601	100184.867	90.93129	111558.2
104	90.931292	111558.2313	4120.3	105887.4
105	4120.300442	105887.3649	424.7023	112155.4
106	424.70226	112155.4328	796.6414	57930.03
116	796.641417	57930.02961	1052.35	60623.6
117	1052.349999	60623.6011	35.42302	13695.52

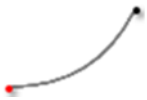
118	35.423023	13695.52125	783.898	112575.8	
119	783.897988	112575.7869	4266.299	92942.84	
120	4266.299428	92942.84409	2765.871	79722.45	
122	2765.870887	79722.45236	2796.635	79758.61	
123	2796.635165	79758.60558	10936.99	91707.97	
124	10936.98784	91707.96778	265.3772	65081.52	
133	265.377239	65081.5239	265.3772	65081.52	
134	265.377239	65081.5239	10936.99	91707.97	
136	10936.98784	91707.96778	10936.99	91707.97	
137	10936.98784	91707.96778	10936.99	91707.97	
138	10936.98784	91707.96778	13008.79	89360.11	
139	13008.78815	89360.11486	10936.99	91707.97	
140	10936.98784	91707.96778	8037.777	55705.78	
162	8037.776586	55705.78051	2789.525	79762.28	
163	2789.524669	79762.27766	3091.58	74385.88	m
			3.09158	74.38588	km
Distance to nearest road from farms that use Phalaborwa abattoir					
Farm number	Distance to nearest secondary road (m)	Distance to nearest national road (m)	813.006	63920.85	
26	813.006037	63920.8542	3838.499	51572.27	
27	3838.498671	51572.26598	6712.298	143930.4	
28	6712.297956	143930.4173	77.79852	79885.12	
29	77.798522	79885.11566	6712.298	143930.4	
30	6712.297956	143930.4173	6712.298	143930.4	
31	6712.297956	143930.4173	241.0462	90088.97	
32	241.04618	90088.96689	75.05403	90075.37	
33	75.05403	90075.36586	108.0866	137282.9	
46	108.086636	137282.9032	8604.836	90712.11	
73	8604.836499	90712.10814	823.4069	201289.1	
78	823.406879	201289.1182	338.5437	69279.51	
79	338.543738	69279.51359	338.5437	69279.51	
80	338.543738	69279.51359	338.5437	69279.51	
81	338.543738	69279.51359	3419.771	67966.61	
82	3419.771036	67966.61492	1743.326	62785.08	
83	1743.326129	62785.08162	6026.68	93156.67	
84	6026.680328	93156.66835	220.4716	77607.47	
85	220.471604	77607.46808	1743.326	62785.08	
86	1743.326129	62785.08162	13492.46	115188.3	
87	13492.45759	115188.3014	9007.328	124461.8	
88	9007.328418	124461.832	13961.58	118950.8	
89	13961.58379	118950.8248	9007.328	124461.8	
91	9007.328418	124461.832	3518.888	49919.45	
92	3518.88802	49919.44592	3518.888	49919.45	
93	3518.88802	49919.44592	8188.648	82741.87	
94	8188.648077	82741.874	669.6519	64063.11	
95	669.651918	64063.10818	9007.328	124461.8	

96	9007.328418	124461.832	4257.124	112453.7	
97	4257.124499	112453.6849	1201.065	111592.5	
98	1201.065313	111592.5454	1660.72	97092.12	
99	1660.719902	97092.11647	358.1994	95598.16	
100	358.199354	95598.16101	2765.871	79722.45	
122	2765.870887	79722.45236	2796.635	79758.61	
123	2796.635165	79758.60558	10936.99	91707.97	
124	10936.98784	91707.96778	265.3772	65081.52	
133	265.377239	65081.5239	265.3772	65081.52	
134	265.377239	65081.5239	10936.99	91707.97	
136	10936.98784	91707.96778	10936.99	91707.97	
137	10936.98784	91707.96778	10936.99	91707.97	
138	10936.98784	91707.96778	13008.79	89360.11	
139	13008.78815	89360.11486	10936.99	91707.97	
140	10936.98784	91707.96778	2789.525	79762.28	
163	2789.524669	79762.27766	4728.222	92952.76	m
			4.728222	92.95276	km
Distance to nearest road from farms that use Thabazimbi abattoir					
Farm number	Distance to nearest secondary road (m)	Distance to nearest national road (m)	4.97732	67090.22	
8	4.97732	67090.21782	1372.15	5525.898	
9	1372.150383	5525.898142	292.102	67577.39	
10	292.10204	67577.39292	292.102	67577.39	
11	292.10204	67577.39292	5096.994	1485.268	
12	5096.99393	1485.26761	155.2738	10019.87	
13	155.273788	10019.87438	31.99545	3497.135	
14	31.995453	3497.135174	7713.113	5540.085	
125	7713.113247	5540.08531	3807.584	1221.212	
126	3807.584009	1221.211977	38.09664	11310.41	
127	38.096637	11310.40616	105.7052	12037.47	
128	105.705208	12037.46843	378.6247	31800.94	
129	378.624747	31800.94075	239.1469	31540.28	
131	239.146878	31540.27882	1450.477	116209.3	
132	1450.476736	116209.2907	506.733	115360.3	
154	506.733043	115360.252	1450.477	116209.3	
164	1450.476736	116209.2907	1450.477	116209.3	
165	1450.476736	116209.2907	1434.472	45894.81	m
			1.434472	45.89481	km

8.3 Appendix 3: Connectivity between municipalities

Graph Metrics											Other Columns			
Vertex	Subgraph	Degree	In-Degree	Out-Degree	Betweenness Centrality	Closeness Centrality	Eigenvector Centrality	PageRank	Clustering Coefficient	Reciprocated Vertex Pair Ratio	Add Your Own Columns Here	geographic (latitude) South	geographic (longitude) East	To Auction Market (Entity 1)	To Slaughter Market 2 (Entity 3)
aganang					0.000	0.077	0.063	0.606	0.000			-23.5913	29.1088		
local slaughter points					21.000	0.143	0.063	3.757	0.000			diffuse around 5km radius	diffuse around 5km radius	Belfast	
tzaneen					0.000	0.077	0.063	0.606	0.000			-23.92722222	30.25263889		
Phalaborwa					21.000	0.143	0.063	3.757	0.000			-25.805	28.74638889	Belfast	Bronkhorstspruit
thabazimbi					0.000	0.111	0.000	0.632	0.000			-24.61888889	27.38527778		
Thabazimbi					10.000	0.200	0.000	2.838	0.000			-24.6	27.4	Belfast	
mokopane					0.000	0.111	0.000	0.632	0.000			-23.5923	28.387		
mogalakwena					0.000	0.111	0.000	0.632	0.000			-23.6634	28.7195		
giyani					0.000	0.077	0.063	0.606	0.000			-23.31	30.70638889		

marulen g		0.000	0.077	0.063	0.606	0.000	-24.2102	30.4075	
tubatse		0.000	0.111	0.000	0.632	0.000	-22.84166667	30.73416667	
Bronkhorstspruit		10.000	0.200	0.000	2.838	0.000	-25.805	28.74638889	Belfast
ba-phalaborwa		0.000	0.077	0.063	0.606	0.000	-23.6928	30.9355	
fetakgomo		0.000	0.111	0.000	0.632	0.000	-24.4437	29.8263	
lepelle nkumpi		0.000	0.077	0.063	0.606	0.000	-24.2991	29.533	
greater giyani		0.000	0.077	0.063	0.606	0.000	-23.29929444	30.65944444	
letaba		0.000	0.077	0.063	0.606	0.000	-24.4322	30.6214	
tzaaneen		0.000	0.077	0.063	0.606	0.000	-23.60166667	30.54416667	
makhado		0.000	0.077	0.063	0.606	0.000	-23.0602	29.9183	
ephraim mogale		0.000	0.111	0.000	0.632	0.000	-24.9298	29.0462	
molemole		0.000	0.077	0.063	0.606	0.000	-23.34861111	29.065	
blouberg		0.000	0.077	0.063	0.606	0.000	-23.27031782	29.12597795	
bela-bela		0.000	0.111	0.000	0.632	0.000	-24.84083333	28.36583333	
modimolle		0.000	0.111	0.000	0.632	0.000	-24.291251	28.113091	

polokwane		0.000	0.077	0.063	0.606	0.000	-24.17611111	29.47236111
elias motsoaledi		0.000	0.111	0.000	0.632	0.000	-24.30694444	29.70236111
musina		0.000	0.077	0.063	0.606	0.000	-22.33805556	30.04166667
makhuduthamaga		0.000	0.111	0.000	0.632	0.000	-24.6956	29.7321