Evaluation of the production systems and constraints of smallholder pig farming in three agro-ecological zones of Mpumalanga province, South Africa

by

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DEDICATION

This dissertation is dedicated to my mother (Ms. Tshifhiwa Makungo), for her unconditional love, always believing in me, all her motivations, her prayers and preaching the educational gospel in my life; and also to my kids, my son, Watshilidzi and my daughter Ankonisaho, to motivate them to grow up knowing that education unlocks the gates to success.

DECLARATION

I **PRISCILLA MUNZHELELE** hereby declare that "**EVALUATION OF THE PRODUCTION SYSTEMS AND CONSTRAINTS OF SMALLHOLDER PIG FARMING IN THREE AGRO-ECOLOGICAL ZONES OF MPUMALANGA PROVINCE, SOUTH AFRICA**" which I hereby submit for the degree of **MASTERS OF AGRICULTURE** at the University of South Africa, is my own work and has not previously been submitted by me for a degree at this or any other institution.

I declare that the dissertation does not contain any written work presented by other persons whether written, pictures, graphs or data or any other information without acknowledging the source.

I declare that where words from a written source have been used the words have been paraphrased and referenced and where exact words from a source have been used the words have been placed inside quotation marks and referenced.

I declare that I have not copied and pasted any information from the internet, without specifically acknowledging the source and have inserted appropriate references to these sources in the reference section of the dissertation.

I declare that during my study I adhered to the Research Ethics Policy of the University of South Africa, received ethics approval (**ETHICAL CLEARENCE NUMBER: 2013/CAES/140**) for the duration of my study prior to the commencement of data gathering, and have not acted outside the approval conditions.

I declare that the content of my dissertation has been submitted through an electronic plagiarism detection program before the final submission for examination.

Student signature:  **Date: 25/05/2016**

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To God be glory

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LIST OF ACRONYMS

AIC	AKAIKE INFORMATION CRITERION
AAO	ANTARCTIC OSCILLATION
ADG	AVERAGE DAILY GAIN
ASF	AFRICAN SWINE FEVER
CSF	CLASSICAL SWINE FEVER
DAFF	DEPARTMENT OF AGRICULTURE, FISHERIES AND FORESTRY
DARDLEA	DEPARTMENT OF AGRICULTURE, RURAL DEVELOPMENT, LAND AND ENVIRNMENTAL SCIENCE
E	EAST
ENSO	EL-NIÑO SOUTHERN OSCILLATION
ESKOM	ELECTRICITY SUPPLY COMMISSION
FAO	FOOD AND AGRICULTURE ORGANISATION
FMD	FOOT-AND-MOUTH DISEASE
GDP	GROSS DOMESTIC PRODUCT
GHS	GENERAL HOUSEHOLD SURVEY
GOF	GOODNESS OF FIT
GPS	GLOBAL POSITIONING SYSTEM
HIV	HUMAN IMMUNODEFICIENCY VIRUS
IOD	INDIAN OCEAN DIPOLE
ILRI	INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE
KM^2	SQUARE KILOMETRE
KZN	KWAZULU NATAL
NAHMS	NATIONAL ANIMAL HEALTH MONITORING SYSTEM
NEPAD	NEW PARTNERSHIP FOR AFRICA'S DEVELOPMENT
PRRS	PORCINE REPRODUCTIVE AND RESPIRATORY SYNDROME
ROI	RETURN ON INVESTMENT
S	SOUTH
SA	SOUTH AFRICA
TB	TUBERCULOSIS
USA	UNITED STATE OF AMERICA

MANUSCRIPT ARISING FROM THIS DISSERTATION

1. Munzhelele, P., Oguttu, J.W. & Fasina, F.O. (2016). 'Is 10-sow unit economically sustainable? A profitability assessment of productivity among smallholder pig farmers, Mpumalanga, South Africa'. ***Onderstepoort Journal of Veterinary Research 83(1), a1011.*** http://dx.doi.org/10.4102/ojvr.v83i1.1011. (**Published on the 12 May 2016**)

2. Priscilla Munzhelele, James Oguttu & Folorunso O. Fasina (2016). Production constraints of smallholder pig farms in agro-ecological zones of Mpumalanga, South Africa. *Submitted to the* ***Tropical Animal Health and Production Journal***.

ABSTRACT

Smallholder pig farming is an important livestock activity in Mpumalanga. The aim of the current study was to investigate whether variation in agro-ecological climatic conditions differently impacts on the small-scale pig production systems in Mpumalanga province and to identify factors that influence production positively or negatively in the various agro-ecological zones. The study was conducted in Mpumalanga province of South Africa in three agro-ecological zones namely the highveld, the lowveld and the midveld. The study followed mixed methods approach, using qualitative and quantitative data. In total, 220 randomly selected smallholder pig farmers were interviewed face to face using pre-tested semi-structured questionnaire. Data was entered into Microsoft Excel2007® spreadsheet, filtered and analysed using Stata v9 (Statacorp., Texas, USA) and Microsoft Excel2007® for frequency, herd-related variables; in addition, some hypothesis were tested using appropriate analytical methods (descriptive and correlation analyses). Associations between agricultural training, government assistance (material or financial) and thirteen herd and farmer-related variables were analysed using multivariable logistic regression model. A pairwise correlation was used where necessary and outputs were generated to associate certain variables and preferred methods including markets, market determinants, treatment methods for sick pigs, feed preference, body conditions of the sows and age at weaning. To integrate economic analyses, a partial budgeting combined with other turn on investment (ROI) model has developed in Microsoft Excel 2007® spreadsheet. The outcomes from the field data obtained including details from published materials were utilized to develop and validate the model. Economic feasibility and viability of a 10-sow unit were tested for a three-year farm operation. The results indicated that smallholder pig farming was predominated by males (64%), age group 51 years and above (54%), black Africans (98.6%) and approximately three-quarters of the smallholder farmers were classified as being poor to just below average. The majority (80%) of respondents had no prior pig husbandry training while few had (33%) received assistance from Department of Agriculture. In terms of stock, mixed breeds (89%) from exotic pigs were mostly kept and the majority (87%) of the farmers kept between 1 – 10 sows in their herds. Many farmers (75%) engaged in bio-security risky behaviour of buying auctioned-sourced boars, free-range boars and untested boars from neighbours and relatives. Few (17%) farmers practiced vaccination and only (10%) kept records of the pigs. The majority of the responses on pre-weaning mortality (50%) and post-weaning mortality (90%)

were within acceptable range of 1-10% and 1-5% mortality rates respectively. The lead causes of mortality were weak piglets and crushing (46%), diarrhea (27%), poor management knowledge (19%) and malnutrition (16%). Fifty-eight percent farrowed ≤10 piglets/born/sow/litter, 44.2% practiced no weaning method, many fed leftovers alone (41.6%), 47% was using self-medication and 41% of the sows were in poor body conditions. It was also discovered that only 27% sold the porkers in less than 6 months of age and local slaughter/sold live (64.4%) was the most preferred market source. A pair-wise correlation showed links that between the feeding of commercial feeds and pigs in relatively good to very good body conditions. Poor body conditioned pigs were positively correlated with the feeding of swill alone. The economic models for a 10-sow unit proved that pig farming at that scale is unprofitable by feeding commercial feed. However, only through a combination of cooperative systems, benefits of economic of scale, reduction of pre-weaning mortalities, and structured government inputs can improve pig production profitable at this scale of production. In addition, agricultural training and government incentives will facilitate improved productivity in smallholder pig farms within the province.

Keywords: Smallholder pig farming, Agro-ecological zone, Mpumalanga

CHAPTER 1.0 INTRODUCTION

1.1. Background information

Agriculture plays an essential role as a source of economy and employment in Mpumalanga province. According to (DAFF, 2013) livestock industry is the largest national agricultural sector contributing about 48% of agricultural output. South Africa produces 85% of the meat required in South Africa (DAFF, 2013). Over the last few years, there has been an increased demand for pork consumption in South Africa; the demand for pork meat has increased by 24% since 2007 Bureau of food and Agricultural policy (South African Government, 2015). According to (DAFF, 2012a) the South African pork industry contributes 2.15% to the primary agricultural sectors with Mpumalanga in six places, contributing 6.1% to national. Mpumalanga province is the second smallest province with only 7.2% out of nine provinces in South Africa (SA). It was also noted that agriculture occupies the largest space of about 68% of the province and contributes about 3.1% to GDP (South African Government, 2015).

The province is situated on the boundary of Mozambique and Swaziland; which puts the province at a high risk of trans-boundary diseases that threaten food security, affects local and international trade and the livelihood of rural communities (Otte *et al.*, 2004); and boundary with Kruger National Park which is a dangerous zone for livestock because of infectious diseases from wild animals. Mpumalanga has five of the former homelands which are Kangwane, Gazankulu, Kwandebele and part of Lebowa and Bophuthatswana; homelands have a high incidence of poverty and food security. The General Household survey (GHS)(2013) report shows that Mpumalanga is number three-province with 29.4% food access problems of the households with inadequate food in South Africa and 31.2% households participate in agricultural activities.

Homelands are mostly occupied by black individuals and it has been reported to decline in agricultural activities (Aliber, 2009). The Statistics South Africa had previously documented that the majority (92%) of the human population in the province are black (Statistics South Africa, 2004), and poverty has largely affected the majority of women and children due to teenage pregnancy and unmarried women (Makiwane *et al.*, 2015). The Mpumalanga is also the second among nine-province with high unemployment rate and poverty of about 28.4% despite being in position four largest economies in South Africa.

Pig farming is one of the most important livestock raised in Mpumalanga by smallholder farmers because pigs require small space for farming. In addition, pig produces large number of offspring on a short gestation period compared to other small stock. Pigs have a gestation of hundred and fourteen days which means it can get pregnant two and half in one year compared to cattle. Smallholder pig farming is the most practiced around the province due to lack of land for subsistence farmers (Makiwane *et al.*, 2012; DAFF, 2013). Pigs commonly found in Mpumalanga province include the Kolbroek, Large White and Landrace breeds and their crosses.

The majority of rural pig farmers practice backyard pig farming while those in the peri-urban areas rear pigs semi-intensively with pig sty usually located around the garbage sites. Pig farming in townships of Mpumalanga is mostly practiced in or around the garbage dumping zones, and this situation might be due to human migration towards urban areas which lead to relative scarcity of farm lands. Such practices are unsafe because raising pigs in the garbage dumping zones come with risks of disease outbreaks (Randolph, 2002; Normile, 2005). Housing, feeding, management and animal health are important for pig farming, but in smallholder pig farming is mistreated, these may be due to lack of knowledge and resources.

Smallholder pig farming in a small-scale relies on family labor and majority of products produced are meant for household consumption. Smallholder pig farming is an important agricultural activity that plays an important role in the livelihoods of households in Mpumalanga province. This may be due to the ability of the pig to convert feeds into the meat as they are omnivores. They are small livestock so they are easy to handle, manage and also to slaughter compared to large stock. According to FAO (2004), agriculture is a key to food security and contributes to poverty alleviation. Pig farming by smallholder farmers in the province is playing a major role to reduce poverty and food security. It plays essential functions in smallholders, as an investment, emergency cash, home consumption (protein/ meat), manure for fertilizing the soil for growing crops (Phengsavanh & Stur, 2006) and they are important assets of the household (Mhlanga, 2002; Drucker and Anderson, 2004).

Smallholder pig farming is faced with a lot of challenges which limits farmers from emerging to commercial status, and, in addition, they are viewed negatively and referred to as non-productive (Kristen and van Zyl, 1998). Smallholder are viewed negatively and not productive for the reason that they do not invest in the profit in the pigs, feeds, housing and maintenance of the pigs, they use available materials to rear pigs such as swills, old fetch to

design pig houses and old oil for dipping despite taking important of certain factors that are essential to successful pig farming which are comfortable clean housing, daily attention, careful observation of the stock, good feeding and water supply. There is no substitute to good husbandry but sadly the above factors are often forgotten in pig husbandry.

Three pig production systems are used for pig rearing in the province. The first one is free-range (Scavengers) system which is a cheap traditional method of rearing pigs, with minimal management as pigs scavenge for feeds and is also fed mostly with swills and with no disease control. Most farmers who use free-range method do not have breeding boars, and the sow scavenges for boars (inbreeding). Free-ranging pigs produces relatively leaner meat as they walk (exercise) around compared to an intensive system. The Department of Health in SA and Woolworth store encourage people to use free range products but the farmers should be advised on how they can improve the system in terms of health, management and biosecurity. Pigs scavenge for feeds in the bush, garbage areas, fields and roads (Taylor & Roese, 2004; Chikwanha *et al.,* 2007). The housing is made of old fence with no roofing which contributes to high mortality during lactation. Piglets require a cool and warm environment as they are born with low body fats.

The second system is the semi-intensive method which is most practiced by smallholder farmers and the farmer is responsible for feeding though the pigs are mostly fed swills. Finally, the intensive production system forms the third category and animals are managed under controlled environment, with expensive management practices in terms of management, feeding, vaccination, health protocols and other needs. This system is largely commercial and contributes tremendously to the national GDP.

The Mpumalanga Department of Agriculture, Rural Development, Land and Environmental Affairs (DARDLEA) have established the programme called "*Masibuyele esibayeni"* meaning back to kraal. The programme is aimed at helping the smallholder farmers to grow by improving the genetic pool of their livestock as their livestock lack good quality genetics. The Department of Agriculture, Rural Development, Land and Environmental Affairs provides farmers with ten (10) sows and one boar with improved genetics for breeding.Smallholder farmers contribute much to families' incomes in Mpumalanga. This programme will help the smallholders in the province to transit from smallholding farming into commercial agriculture, and also improve the genetic pool of the pigs in the province.

In early 2012, an outbreak of African swine fever (ASF) was reported in the province and this greatly affected some major pig production districts in Mpumalanga including Nkangala and Gert Sibande district, and some parts of Gauteng province. The DARDLEA's programme among smallholder pig farmers in the province was severely affected and to date majority of the farmers affected by the outbreak still have empty pig housing facilities. The intervention from the government is required in order to encourage pig farmers especially the smallholders.

In addition to the above, three different agro-ecological zones exist in Mpumalanga province and the contribution of each or any of these zones specifically to pig production has never been evaluated. Makiwane *et al.* (2012) reported that climate change is a factor that affects agricultural production. It is known that weather conditions influence the performance of the animals and pigs are very sensitive to heat. Pigs do not have functional sweat glands that assist with removing of body sweat and have small lungs (Vosloo and Casey, 1993). There is a perception that pigs survive well in cold than in heat these may be due to a reduction of heat stress. In view of the above and since pig production is practiced in Mpumalanga, there is a need to compare the pig management practices in the three ecological zones of Mpumalanga province viz: the Highveld, Lowveld and Midveld and determine the impact of different climatic factors

1.2. Problem statement

There is limited documented knowledge on the production systems, practices and constraints facing smallholder pig producers in South Africa in general and in Mpumalanga specifically. There is a perception that Mpumalanga smallholder pig farmers are not contributing anything to pork sub-sector of the meat industry in South Africa but small-scale pig farming contributes significantly but unbeknown to family incomes in Mpumalanga. Finally, the influence of the different agro-ecological zones on pig production in Mpumalanga has never been investigated.

1.3. Hypothesis

1. Smallholder pig farmers produce efficiently in Mpumalanga and contribute to family incomes of Mpumalanga.
2. Assistance from the provincial and national agricultural authorities impact positively on pig agriculture in Mpumalanga.
3. Different agro-ecological climatic conditions impact differently on pig production in Mpumalanga.

1.4. Purpose statement

The aim of the study was to investigate the production systems, constraints and the effect of different agro-ecological zones in smallholder pig farming Mpumalanga province.

1.5. Research questions

1. Is small-scale pig farming profitable in Mpumalanga and does it contribute to family incomes?
2. Does different agro-ecological climate influence pig production in Mpumalanga?
3. Does assistance from agricultural authorities promote pig production in Mpumalanga?

1.6. Aims and objectives

1.6.1. Aims

The aim of the study was to investigate whether variation in agro-ecological climatic conditions differentially impact on the small scale pig production systems in Mpumalanga Province and identify factors that influence production positively or negatively in the various agro-ecological zones.

1.6.2. Objectives

i. To identify the production systems and production constraints of smallholder pig farming in Mpumalanga.
ii. To compare the pig management practices in the three agro-ecological zones of Mpumalanga province viz: the Highveld, Lowveld and Midveld and determine the impact of different climatic factors.
iii. To determine the effect of small-scale piggery production system in poverty alleviation within the Mpumalanga province.

1.7. Anticipated benefits of the study

i. The study will assist the Department of Agriculture, Rural Development, Land and Environmental Affairs, Mpumalanga in planning on focus areas for pig production system among smallholder farmers in the province.
ii. Data on the smallholder pig farmers in Mpumalanga will be updated for use in surveillance, epidemiology and other interventions like training and funding needs to smallholder farmers.
iii. Some of the knowledge gaps in animal agriculture within the province will be filled.
iv. There will be a better relationship between the staff of the Department of Agriculture, Rural Development, Land and Environmental Affairs, Mpumalanga and the smallholder farmers in Mpumalanga.
v. The results of this study will be used as a guideline and will improve the standard of smallholder pig farmers in the province.

1.8. Ethical consideration

This project was conducted with the College of Agriculture and Environmental Sciences, UNISA (CAES) Ethical approval number: 2013/CAES/140. The content of this document was finalized based on the conditions that:

i. All ethical issue has been cleared with other appropriate authorities (Department of Agriculture, Rural Development and Land Administration, Mpumalanga Province and Animal Use and Care Committees.
ii. No animal was used directly in the study but the study leader and her assistants have adhered to prescribed protocol that gives the pigs maximum comfort in their environment during the study.
iii. The protocol excluded the use of human subjects. However, in view of the detailed information that was collected from the farms for analysis, each participating farmer gave written or oral approval indicating their willingness to participate in the study. A copy of a self-explanatory consent form is attached in Appendix 2. Each participant was allowed free choice to discontinue participation at any stage of the study.
iv. The researcher was also bound to observe maximum bio-security and minimize a risk of infections between farms during the course of the study.

1.9. Components of the report

Chapter 1 presented background information on Mpumalanga province and smallholder pig farmers. The objectives of the work were highlighted in bullets points and research hypothesis, anticipated benefits of the study and ethical considerations were listed. **Chapter 2** focuses on the theoretical and practical frameworks (literature review) both from the international and local perspectives. In **Chapter 3**, the research methodology which covered the study area in details, research design, data collection procedures, data analysis techniques and the limitation of the study were described in details. **Chapter4** specifically focused on the results and their interpretations. **Chapter 5** discussed the results, the implications thereof and blended it with previous knowledge. Some valuable lessons and parallels were drawn from the outcomes. Finally, **Chapters 6** illustrated the conclusions and makes valid recommendations based on the results and discussion. A brief summary of the key findings was also made. At the end of this chapter, a list of the literature used in this study was prepared and inserted.

CHAPTER 2.0 LITERATURE REVIEW

Livestock production plays a significant role in the national economy of South Africa. Specifically, livestock farming contributes approximately 48% to the agriculture's economy (South Africa government, 2015). Pigs are one of the livestock raised in South Africa and the country is able to export surplus pigs to regional and neighbouring countries. This was confirmed in 2012, where 2 million tons of pork was produced and only 250 tons was consumed in the country (DAFF, 2012). Therefore, South Africa can be said to be self-sufficient in terms of pork production. Pig production is one of the activities which are important in the households of Mpumalanga, but there are problems that smallholder pig farmers in Mpumalanga are facing and the management systems which are undocumented.

2.1 Poverty alleviation through smallholder pig farming

*"Most of the people in the world are poor, so if we knew the economics of being poor we would know much of the economics that really matters. Most of the world's poor people earn their living from agriculture, so if we knew the economics of agriculture we would know much of the economics of being poor" (*Shultz, 1979).

Approximately 78% of the underprivileged rural societies in the world are reported to be dependent on agriculture for their livelihood (FAO, 2015). During the state of the nation address in 2010, it was emphasized that food security was one of the critical top priority in South Africa for the year 2010/2011. South Africa has relatively high level of poverty, and Mpumalanga province recorded the third highest unemployment rate of 31.6% in the year 2012/2013. Whereas agricultural sector contributed 9.9% of the employment figures in 2012/2013 in South Africa, approximately 36.2% of the individuals in the province live below the poverty line. According to the Bureau for market research, the household of four should a minimum monthly income of at least R2795 while the household of six should have R3884 (Mpumalanga Department of Finance, 2014).Smallholder pig farming plays a vital role in the livelihoods of the rural individual farmers and their households. Pigs farming only require minimum and low inputs to operate (Tekle *et al.,* 2013).In addition, smallholder farming can be prolific and successful if provided with necessary assistance and this can result in poverty reduction and agricultural development (Jama and Pizarro, 2008).

Mpumalanga province is a home of the five former homelands. According to Machethe (2004), about 65% of the poor in South Africa are located in the former homeland. In addition, South Africa's former homelands are mainly dominated by African smallholder farmers with approximately about 16 millions of hectares of the total agricultural lands (Fenyes and Meyer, 2003). Furthermore, the majority of smallholders were reported to have a low level of education and low in financial power. Smallholder pig farming in Mpumalanga province can enhance the employment status of the rural farmers (Nath *et al.,* 2013). They need to improve some of the production systems such as moving from backyard farming and limited resource-based agriculture to expand the enterprise, and improving old technologies which are currently practiced and improvement of low inputs in the enterprise. They are well known for marketing their products at the informal markets (DAFF, 2012). The inability to access the formal market might be the most influential factor why this farming system predominates.

Many researchers around the world have reported various reasons for the rearing of pigs at smallholder level (Wabacha *et al.,* 2004; Kagira *et al.,* 2010; Mutua *et al.,* 2010). The majority of smallholders in rural settlements kept pigs to generate income (Rangnekar, 2006; Kagira *et el.,* 2010; Halimani *et al.,* 2012; Kambashi *et al.,* 2014); others as forms of investment and to reduce socio-economic risks (Huynh *et al.,* 2007), to provide protein to the members of the household and manure to fertilise the crops (Ajala *et al.,* 2007). They were also used as gifts for weddings and festive seasons (Mys, 2004; Lee *et al.,* 2005). Pig production is a viable livestock system that plays a major role in the smallholder as a source of income, meat for household consumption and sale (Wabacha *et al.,* 2004; Kagira *et al.,* 2010; Mutua *et al.,* 2011; Petrus *et al.,* 2011; Muhanguzi *et al.,* 2012). In addition, there are households that rear pigs only for sale (Lee *et al.,* 2005; Tekle *et al.,* 2013).

The early maturity, fast turnover and ease of conceiving under the vulnerable environment and profitability may be the main motives for the pig farmers (Lekule and Kyvsgaard, 2003). This is due to their ability to convert available resources and low-value waste products into high value (NEPAD, 2008). More particularly because they require minimal inputs and labour, have high feed conversion efficiency; produce a large number of offspring and short gestation (Lekule & Kyvsgaard, 2003; Mutua *et al.,* 2010). For these reasons, the smallholders consider pig farming to create jobs among villagers (Rangnekar, 2006).

In other countries, the manure from pigs was used to process the fuel, for methane production, for cooking stoves and also for feeding fish (Dietze, 2011). With South Africa facing load shedding and a high price of electricity, the use of methane can assist the country to reduce the burden placed on electricity grip used and this pig manure can be an effective alternative to energy and some source of income. In addition, manure is used to fertilise organic crops which are considered healthy to the environment. Finally, food security will be enhanced amongst the disadvantaged groups in South Africa through pig rearing.

Food security is described as the ability of the individual to have access to sufficient food (Du Toit, 2011). Lapar & Staal, (2010); Ouma *et al. (*2013) views smallholder farming as a tool to better the social security for poor households by generating income for the poor. The livestock production is also regarded as an important component with significant potential to improve household food uncertainty and reduce poverty in the poor rural areas (Musemwa *et al.,* 2008). More especially pigs because they can be reared at the backyard of the house with simple available materials and could be fed leftover feeds (Muhanguzi *et al.,* 2012).

2.2 Pig production systems

Breeds selection in pig husbandry is the most important factor that farmers should consider when planning to start pig farming (Dietze, 2011). Different kinds of breeds are preferred by farmers in different places around the world (Drucker and Anderson, 2004). In Cambodia, Indigenous breeds were preferred than exotic breeds because people believe that they are free from antibiotics (IRLI, 2011). Predominant pig farmer population in Columbia (Ocampo *et al.,* 2005) and North-East Hill regions of India preferred indigenous breeds but poor growth was a hold back (Nath *et al.,* 2013). In South Africa, in Limpopo province about 61.18% reported preferring indigenous breed and the remainder, the exotic breeds (Mokoele *et al.,* 2014). Indigenous pigs raised in the smallholder were reported to have low average daily gain (ADG) (Chimonyo *et al.,* 2010; Mutua *et al.,* 2012). The low ADG is believed to be caused by the kind of feeds that are fed by most smallholder pig farmers (Mutua *et al.,* 2012). According to Muhanguzi *et al.* (2012), the development of smallholders through the rearing of indigenous is very slim because of a low rate of replacement stock and the hindrances of poor genetics and growth.

However, cross-bred were leading breeds in Sikkim Himalayan region of India (Deka *et al.,* 2007; Nath *et al.,* 2011). Exotic breeds are considered as breeds that have low tolerance to

tropical diseases and expensive to maintain (Chimonyo, 2005). Exotic breeds were mostly observed in commercial enterprises and exotic pigs in commercial enterprises were reported to achieve the live weight of 100kg within 180 days (Vosloo and Casey, 1993). While in the smallholding pig enterprises, pigs were marketed late due to their slow growth (Nath *et al.*, 2011). Deka *et al.* (2014) stated that indigenous breeds are resistant to different diseases adapt and reach sexual maturity later in the harsh environment compared to exotic breeds. The smallholder pigs are mostly fed locally available which are used for maintenance of the pig, instead for reproduction and health (Vosloo and Casey, 1993). As a result of the above, they are well known for poor carcass quality and excessive fats. Despite the poor body quality and excessive fats, in East Asia and South Asia indigenous breeds were in high demand and high price were charged in rural areas (Deka *et al.,* 2007).

In the smallholder pig production, the system is usually associated with diseases transmission (Tomass *et al.,* 2013) and recent study in Ethiopia reported that the scavenging system was becoming unpopular as community was fighting against the scavenging system of the livestock in garbage sites and roadsides (Tekle *et al.,* 2013).

The absolute definite of the smallholder pig farms and population differ from country to country. For example, approximately 80% of pigs reared in Vietnam, Laos, Philippines and Cambodia are on smallholder level (Huynh *et al.,* 2007). In South Africa, smallholders pig farmers are characterized by ≥50 sows herd, while in Philippines and Vietnam, the farm should, at least, have ≥20 sows and Myanmar, Cambodia and Laos it is ≥5 sows (FAO, 2005), while for the whole of South East region is just as little as three sows (Deka *et al.*, 2007).

2.3 Importance of pigs

Pig production is one of the main agricultural key players in the rural communities and it plays a vital role as all the pig products are used for different motives. Fats from pigs were used as cooking oil and are also believed to chase away evil spirits if mixed with other herbs (Madzimure *et al.,* 2012). Whilst, Phengsavanh *et al.,* (2011) claim that in some remote areas pig fats was the only source of cooking, oil fats were also processed to lard for cooking and as lubricants cosmetics(Herren, 2011). In South Africa, in Kwa-Zulu Natal (KZN) fats were used to soften the traditional clothes that are worn by women during traditional ceremonies (Gcumisa, 2013) and there are those who use it for religious rituals (Ocampo *et al.,* 2005). Despite the fact that there are people who do not consume pork due to religious reasons

(Gcumisa, 2013), but surprisingly, research in Ethiopia revealed the rearing of pigs by people whose religions prohibit the consumption of pork (Tekle *et al.*, 2013). These might be the fact that the turnover of pig farming is fast and at low maintenance cost.

Pork is the most consumed meat in the world with high volume of protein (FAO, 2001; Nath *et al.*, 2011). The high volume of protein is beneficial to reduce food insecurity in young children as it provides a balanced nutrition such as essential amino acids, vitamins and iron (Ajala *et al.,* 2007; Dietze, 2011). Other pig products include blood and hairs which is used for making and blood meal brushes.

Pig rearing is women dominated activity in most countries (Njuki, 2010; Chittang *et al.*, 2012; Muys, 2004). In addition, they also owners smallest livestock at the household and backyard (Ouma *et al.*, 2013; Rangnemar, 2006).Most of the women and children that were involved in pig rearing were described as poor and disadvantaged members of the communities (Mashatise *et al.,* 2005; Rangnemar, 2006; Halimani *et al.,* 2012). In India, women were reported to be the only one involved in looking after new born (piglets after farrowing) and sick animals (Rangnemar, 2006). Low input costs on pig house and ability to convert waste to feed may be the main reasons women are the majority in the smallholder pig farming (Waiswa, 2005). This kind of practice assists women in being financially independent and to be able to provide for their households. However, in some surveys, smallholder pig farming is a male dominated activity (Nath *et al.*, 2013; Mokoele *et al.*, 2014).

2.4 Pig housing

Accommodation for pig is important in pig production because it protects pigs especially suckling and growing pigs from predators and diseases (Kyriazakis and Whittemore, 2006). It also protect the piglets after farrowing from hypothermia ensure high survival of the piglets through prevention from crushing. Crushing of piglets by sow was reported as one of the lead causes of deaths in pig farming (Dietze, 2011). Unfortunately, smallholder farmers use simple available materials for the construction of the pig houses (Ajala *et al.*, 2007; Kumaresan *et al.*, 2009; Muhangazi *et al.*, 2012 and Tekle *et al.*, 2013).Whereas pig building materials should be free from hazardous materials such as toxic paints, toothed edges and non-insulated materials(Vosloo and Casey,1993), some pig smallholder farmers use burnt brick and, old corrugated irons and woods to construct pig houses(Nsoso *et al.*, 2006; Ajala *et al.*, 2007; Kambashi *et al.*, 2014).

However, there are different types of housing system in pig production enterprise. In intensive pig production system, market efficiently and profitability were achieved and improved house (Muys, 2004). The pigs reared in this system grow faster than the pigs reared in semi-intensive and free range systems (Sather *et al.,* 1997). Cameron (2000) reported that 80% of the pigs produced in Thailand are produced through an intensive farming system with 56% of farmers having more than 1000 pigs. In the semi-intensive system, pigs are well managed and the animals manure is used for fertilizing crops (Vosloo and Casey, 1993). This system may consist of a large paddock and shelter for the pigs with the aim of avoiding the use of liquid manure and mechanical ventilation (Gentry and McGlone, 2003). This system is believed to improve the pork quality and have poor daily weight gain and higher average daily feed intake (Anonymous, 2015). Pigs kept in semi-intensive system had lower average daily gain (ADG) compared to intensive pig production system (Enfält *et al.,* 1997; Sather *et al.,* 1997). Semi-intensive is associated with environmental factors like nitrate leaching, soil compaction, removal of vegetation, and soil erosion may be observed (Edwards, 1999).

In the free range housing system, mostly practiced in rural areas and it is characterized by poor reproduction, poor growth performance, high mortality rates, and highly vulnerability to parasites (Vosloo and Casey, 1993). Pigs wander freely during the dry season and mostly confined during crop planting and harvest periods (Ocampo *et al.,* 2005). They also wander across the streets to search for feeds (Tekle *et al.,* 2013). This system keeps the input cost low as pigs are allowed to scavenge for food during dry seasons when there are no crops planted (Lekule & Kyvsgaard, 2003; Mutua *et al.,* 2010). Moreover, free range pigs are associated with poor welfare and economic inconvenience (Vanheukelom *et al.,* 2012). They use high energy level on body maintenance and on stress caused by lack of housing and scavenging (Carter *et al.,* 2013). Therefore, piglets in this system become more independent at an early age as they learn to consume solid feeds at an early age (Vanheukelom *et al.,* 2012). Local breeds are more widespread in this system as they are more tolerant to diseases and can tolerate low quality feeds (Muys, 2004).

2.5 Production constraints in smallholder pig farming

Nutrition is a primary function in animal production; instead, it is mostly overlooked in smallholder farming. Feeds costs contribute approximately 70% to 80% of the total costs in pig farming in the commercial setting (Visser, 2004). Improved feed conversion rates boost the outcomes in terms of growth rates and reproductive performance of the livestock (Steinfeld *et al.,* 2006). Pigs in smallholder system are mainly fed with feeds available than

on nutritional feeds required in different stages of the age (Lemke *et al.* 2007), using the locally available feeds. Several authors reported feeds as major production constraints (Chikwanha *et al.* 2007; Kagira *et al.* 2009).

The feeding of swill has been reported in smallholder pig farming in different countries (Kumareresan *et al.*, 2009; Petrus *et al.*, 2011; Ouma *et al.*, 2013; Mokoele *et al.*, 2014). The swills fed to pigs were from the restaurants and waste from the fruits and vegetables (Tekle *et al.*, 2013). In addition, Mutua *et al.* (2012) indicated that swill contains high carbohydrates and unbalanced nutritional values. Whilst Vosloo and Casey, (1993) disagree with Mutua et al. (2012), they reported that kitchen swills can provide balance diet but can also be deleterious to livestock which can result in botulism and other diseases. Peri-urban farmers have the advantage of getting swills which contain more protein as they get swills from city restaurants and hotels (Carter *et al.*, 2013). Depending on the swill used, underfeeding may exist due to inconsistency of feeds from the different sources(Phengsavanh *et al.*, 2010; Nath *et al.*, 2013).In addition, nutrition is important in pig farming because it influence the production of quality milk during lactation and for faster growth rate (McCosker, 2014). Nevertheless, the motive for using cheap feeds (swill) is the high price of grains (Kagira *et al.*, 2010; Muhanguzi *et al.*, 2012). The high price of the feeds is influenced by the competition for grains by human and animals; and the climate change (Muhanguzi *et al.*, 2012).

Breeding and selection boar have a crucial role to play particularly in the farming system were natural mating is practiced. There is a negative perception about keeping breeding boar in smallholder pig farming because it is only used during breeding thus discourages farmers from keeping their own boars. Several researchers reported the shortage of breeding boars in different countries (Chittavong *et al.*, 2012; Mutua *et al.*, 2013; Madzimure *et al.*, 2013; Kambashi *et al.*, 2014). The high cost of boar maintenance was one of the constraints (Njuki *et al.*, 2010). Therefore, smallholder farmers preferred to borrow boars for breeding from relatives, neighbors (Tekle *et al.*, 2013) or to free roam sows to get boars for breeding or select from their own herd (Nath *et al.*, 2013). However, this method is risky when it comes to animal health, i.e. if one boar is sick, he will transfer the diseases to different sows around the area. The payment of the service rendered by the boar was repaid by giving the boar owner some piglets after the sow serviced had farrowed (Mutua *et al.*, 2011; Mudzimure *et al.*, 2013) and by means of cash in other areas (Khambashi *et al.*, 2014).

In the commercial system, sows to be mated are preselected based on certain criteria. Whereas the selection is important, it is mostly ignored in smallholder pig farming which results in poor pig quality and inbreeding. Inbreeding in smallholder pig farming and its limitations have been emphasized (Lanada *et al.*, 2005; Ajala *et al.*, 2007; Petrus *et al.*, 2011; Halimani *et al.*, 2012; Madzimure *et al.*, 2012; Montsho and Moreki, 2012). Inbreeding is reported to be caused by lack of resources, low level of education and unplanned production system (Madzimure *et al.*, 2012) and housing system such as free roam. Inbreeding causes the loss in heterozygosity and increases homozygosity which can result in increased lethal genes. It also spoils the good genotypes as closely related animals are mated. Brandt *et al.* (2002) had indicated the negative effects of litter size and low birth weight. The lack of skills on pig enterprise in smallholder pig farming was also reported to cause the reduction in pig reproduction, increase mortality and poor growth (Vosloo and Casey, 1993).

In smallholder pig system, young gilts are mated at early age, which has complication on pig production and offspring as it results in the birth of small litters, low birth weight consequent weakness and poor subsequently poor growth (Mugs and Westeubrink, 2008) and poor rearing ability (Smits and Collins, 2009). Smits and Collins (2009) reported that gilts farrows litters with insufficient immunoglobulin protection which protect them from diseases which result in mortality. The offspring born to gilts were reported to be lighter at birth when compared to offspring to mature sows (Tantasuparuk *et al.*, 2001). The piglets from gilts were as well reported to grow slow compared to piglets born to mature sows (Miller *et al.*, 2008). The mortality of the piglets will reduce the number of pigs to be sold (Lanada *et al.*, 2005). However, the selection of good breeding sows will reduce pre-weaning mortalities (McCosker, 2014) and culling of old sows and excessively fat sows will ensure good and safe farrowing (Kirkden *et al.*, 2013). The good breeding sows should farrow twice to ≥23 piglets per annum, but this is a hard target smallholder pig farmers.

Pre-weaning mortality is one of the most reported constraints in pig production (Phengsavanh, 2011; Hughes and Wettere, 2012). Borges *et al.* (2005) reported that pre-weaning mortality mainly occurs due to litter size; sow body condition, nutritional deficiencies, diseases and stress caused by environmental temperatures and human intervention. In addition, the genotypes, management, pig facilities, under nutrition during gestation, diseases, lack of knowledge f housing and environment, trauma, low viability and large variations in the birth weight of the litters also contribute to pre-weaning losses (Dial *et al.*, 1992; Koketsu *et al.*, 2006; Shankar *et al.*, 2009). Therefore, pre-weaning mortality

reduces the profitability in pig farming (Dial *et al.*, 1992; Borges *et al.*, 2005, Persdotter, 2010).

In this regard, mortalities during pre-weaning generally occur in the first week of birth and are connected to overlay or crushing by the sows. Wachaba *et al.* (2004) have reported 69% of deaths due to overlay, whilst Phengsavanh and Stur (2006); Phengsavanh *et al.,* (2010) reported 30 – 50% in Lao people's democratic republic and 18% was reported in Australia (McCosker, 2014). The overlay occurs mostly when the sow lay down and rolls while sleeping (Damn *et al.* 2005, cited in Kirkden *et al.* 2013). Furthermore, the number of teats in the sow plays a critical role after farrowing; teats should be count to foster piglets if piglets farrowed are more than the available teats on the sow to prevent mortalities caused by starvation (Kirkden *et al.*, 2013).

It is perceived that feeding of energy feeds during farrowing reduces the total farrowing time and pre-weaning mortality rates (Hughes and Wettere, 2012). Whilst Campos *et al.* (2012) believes that piglets with heavier livers have high survival rate and these may be reached by feeding nutritive feeds on the last days of the gestation. Dial *et al.* (1992) highlighted the importance of day one on lactation and heat supplementation for piglets to minimize the pre-weaning mortalities in pig farming industry. During weaning, piglets undergo severe physiological and social challenges which can lead to poor performance, exposure to diseases and consequently mortality (McCosker, 2014).

Disease outbreak is one of the biggest threats to pig production for the reason that it results in economic losses. This may include zoonotic diseases like *porcine cysticercosis, trichinellosis, toxoplasmosis, Trypanosomabrucei and Gambiense* infections (Kambashi *et al.*, 2014). Others diseases like *Ascarissuum* and *Cryptosporidium spp* are economically important parasites (Tomass *et al.*, 2013) and African swine fever (ASF) which threatens the food security of affected country (Kambashi *et al.*, 2014). Moreover, in Ethiopia, the 5.8% of pigs during slaughter were identified with *tuberculosis* (TB) and the author also emphasized farmers practicing scavenging system to be sentient of diseases like HIV and TB as they relate (Arega *et al.*, 2013). Renaudeau (2009) believed that pig diseases are caused by the dreadful hygienic practices which are employed in pig farming.

The lack of early disease identification is the cause of high mortalities in smallholder farming (Kagira *et al*., 2010). In addition, the lack of skills from extension services, veterinarians and

preventive health care (Tekle *et al.*, 2013). Diseases in pig farming affect the livelihoods of the individuals who depend on the pig enterprise. The high prices of the medication are believed to be main constrained for smallholder farmers (Muhanguzi *et al.*, 2012).
In addition, the use of the ethnoveterinary for the treatment of animal diseases remained a great challenge in smallholder farming. This is due to seasonal availability of some medicinal plants, scarcity of treatment of epidemical diseases and difficult to standardize the herbal remedies (dosage) (Mathias and McCorkle, 1989). The study at Central Uganda also showed the use of ethnoveterinary practice by smallholders as a way to reduce input factor (Nath *et al.*, 2011; Muhanguzi *et al.*, 2012).

According to Muhanguzi *et al.*, (2012) and Mokoele *et al.*(2014) poor knowledge of bio-security and poor market access makes smallholder farmers market thus facilitating inter-provincial animal disease transmission. African swine fever endemic provinces were required to construct a double fence to strengthen bio-security (Du plessis *et al.,* 2012). It has been suggested that controlled movement of pigs can result in disease management (Huynn *et al.*, 2006) and the provision of good housing system will prevent the build-up of pathogens associated with the muddy environment (McCosker, 2014).

Access to market is one of the frustrating issue in pig business and thus make them sell live pig at a low price (Mtileni *et al.,* 2006, Muhanguzi *et al.*, 2012), due to their lack of negotiation skills (Van Schakwyk *et al.,* 2011). South Africa is well known for housing many rural areas which were formerly homelands within adequate market access and infrastructure to transport the pigs to the market (Van Zyl and Binswanger 1996). The marketing constraint in smallholder is also caused by lack of knowledge and resources to achieve the required market grades and standards (Mwaniki, 2006; Van Schakwyk *et al.,* 2011), the pigs in smallholder farms were characterized with diseases, sickness from bacteria, viruses, and parasites that jeopardize the marketing value (Ajala *et al.*, 2007). The unreachable market limits farmers from marketing the pigs (Huynn *et al.*, 2006). In addition, lack of support institution, marketing policies and a high cost of exportation also limit smallholders to assess the international markets (Mwaniki, 2006). The long distance from the area of farming to market is limiting the farmers, long distance as much as (±400km) to sell the livestock (Mokoele *et al.* 2014). To overcome this, smallholders should identify the market before production, research the product standard required, quantity and quality required (Mwaniki, 2006).

Furthermore, the market is also influenced by the choice of the breed practiced in smallholder level. Smallholder prefers indigenous livestock even though they have a negative financial contribution on profit (Rangnekar, 2006). Pig production is affected as a result of seasonal fluctuation in pig market price, competition, and extreme distances to transport pigs to market (Kangira *et al.*, 2010). The transportation in pig production enterprise is very important for pigs to meet good market price (Dietze, 2011). Therefore, poorly transported pigs causes bruise damages to the blood vessels. Good transportation of the pigs to the market will make the farmer to receive good market price and that enhance the profit margin of the business.

Agricultural activities has been reported to be declining as a result to poor services rendered by extension officers (Jama and Pizarro; 2008; Montsho and Moreki, 2012; Muhanguzi *et al.*, 2012). The decline in pig production is pointed on extension officers; they are believed to have insufficient training in animal husbandry (Moreki and Mphinyane, 2011). Whilst Muhanguzi *et al.* (2012) associates the poor agricultural services with the low salary paid to agricultural advisors. This can also be associated to shortage of the extension officers in agricultural institution.

2.6 The influence of ambient temperature in pig farming

The climate is influenced by the latitude that determines the amount of the solar radiation which is influenced by the distance from the sea and the height above the sea level (Jager 1993, cited by Maree and Casey). South Africa has four climatic seasons which are spring, summer, winter and autumn. Each season has different weather conditions, temperature and length of day. There are eleven main climatic zones namely, desert, the arid (steppe), the subtropical wet (Lowveld), Highveld, Drakensberg, Sub-tropical east coast, Southeast coast, south coast, Karoo, Bushveld and the Mediterranean (Tadross and Johnston, 2012). Each of the climatic zones has different temperature especially in summer and winter due to variations in elevation, terrain and ocean currents more than the latitude. The sea also has a vital role on the climate as areas close to the sea are warm in summer and also warm in winter.

The ecological zones are influenced by the different climatic system which are El-Niño Southern Oscillation (ENSO), the Antarctic Oscillation (AAO) and the Indian Ocean dipole (IOD) (Tadross and Johnston, 2012); and Acocks (1988) report that climate influenced variation in rainfall, temperature, humidity and soil types. Therefore, agro-ecological zone definite is a land resource mapping unit, defined in terms of climate, landform and soils,

and/or land cover, and they have the specific range of potentials and constraints for land use (FAO 1996). The agro-ecological zones also have various climatic conditions and vegetative biomes (Acocks, 1988). Based on the above, Mpumalanga province has three agro-ecological zones with different ambient temperatures which have a major effect on the livestock production (McManus *et al.*, 2011).

Muys (2004) point out that pigs respond to temperature changes due to their lack of skin pigment and sweat glands. The body temperature plays an input role in proper growth rate. There are different environmental requirements for pig farming. High ambient temperatures potentially have several influences on the sow (Britt *et al.,* 1983), boar semen quality and decrease semen concentration (Kunavongkrit and Proteep, 1995) and appetite, reduce pig growth and feed conversion efficiency (Vosloo and Casey, 1993). These observations were supported by previous studies by Kunavongkrit and Heard (2000) where poor performances were observed during farrowing in the hot climate. Typically, hot climate causes anoestrus which causes delay anovulatory oestrus (Kunavongkrit and Proteep, 1995). Paterson *et al.* (1978) have earlier observed a large number of infertile sows which were mated during high environmental temperature exceeding 32^{o}C. However, it is possible that these poor performances were also associated with poor quality feeds, poor genetics and diseases (Fredrick and Osborne, 1977).

Extremely low temperatures also have an influence on pig farming, as it causes slow growth because more feeds are used for the maintenance of the body temperature, the reduction of resistance to infection and the increase of mortality in young piglets (Vosloo and Casey, 1993). Koketsu *et al.* (2006) have suggested that housing and management style in different countries will be due to different seasonal types and climatic conditions.

A suggested ambient temperature for pigs in different stages of production has been outlined in the table below.

Table **2.1: Temperature required by pigs during different production stages**

Production stage	Optimum Temperature
Piglets (neonatal birth to 1 week)	**32 – 37^{o}C**
Piglets (1 – 3 weeks)	**25 – 32^{o}C**
Piglets (4 – 5 weeks)	**20 – 25^{o}C**
Growing pigs (25 - 50kg)	**18 – 25^{o}C**
Finishing pigs (20 – 100kg)	**18 - 24^{o}C**
Pregnant sows in groups	**15 – 18^{o}C**
Pregnant sows individual confined	**13 – 21^{o}C**
Lactating sows	**15 – 18^{o}C**
Non-pregnant sows and breeding boars	**5 – 20^{o}C**

Source: (Kyriazakis and Whittemore, 2006)

2.7. Summary

Smallholder pig farming plays a significant role in South Africa, especially in Mpumalanga province. The province has a high level of unemployment, poverty, low educational and financial power due to five former homelands during the apartheid regime. Smallholder pig production is a source to create job and reduce food insecurity. In hence, pigs grows fast, with low input to operate and can be practiced at the backyard. Pig production is a tool to better the social security for poor households by generating income, gives financial stability to women, and provides meat for household consumption, emergency during financial needs, investment and for religious rituals. The most important part is the marketing of all pig products compared to other livestock.

In animal production, nutrition is a primary key but in smallholder pig farming is overlooked. To produce good quality pigs, different age group requires different feeds composition. In smallholder, pigs are fed locally available feeds and are also underfed which contribute to mortality. In addition, pig housing is important in pig production but is mostly ignored which result in high mortality during the lactation period. The free range and semi-intensive systems are the most dominant systems preferred in smallholder pig farming. Even though they have many disadvantages farmers prefer them due to cheap implications involved.

Breeding is challenged with a risky behaviour of borrowing boars from neighbors and relatives, renting of boars, buying of auctioned boars, free roaming of sows and selection of boars from an own herd. The method of using untested boars involves spread of diseases amongst farmers and inbreeding which destroys the genotypes of the pigs in smallholder pig production. The majority of gilts in smallholder are mated before they reach maturity age for mating, inbreeding and mating of old sows contribute to low farrowing rate and high mortality rate. The high mortality in smallholder pig farming usually occurs due to nutritional deficiencies, diseases, stress and during farrowing.

In conclusion, diseases, lack of negotiation skills, lack of knowledge, lack to produce market grades and required standard on the abattoirs; and rearing of breeds that are unacceptable to market are the main market constraints that the smallholder pig farmers are facing. The poor quality pigs produced in smallholder pig farms result in low return (price) and condemnation in the abattoir. Practicing good pig management can enhance the pig production and can also expand the output in the smallholder pig farming.

CHAPTER 3.0 RESEARCH METHODOLOGY

3.1 Materials and methods

3.1.1 Study area

The study was conducted in Mpumalanga province "*Place where the sun rises*" in South Africa (**Figure 3.1**). The province is situated in the Eastern part of South Africa with the geo-coordinates 26.0000° S, 30.0000° E. It is bordered by the two countries namely Mozambique and Swaziland; and is also contiguous to four provinces of South Africa including the Free State, Gauteng, Limpopo and Kwazulu Natal. The province shares extensive hectares of land with the Kruger National Park in the lowveld regions. The total land area in the province is 78 370km^2, which is 6.3% of the total of South Africa, a second smallest province in South Africa. The province has three municipality districts namely Gert Sibande, Nkangala and Ehlanzeni and with 19 local municipalities. All districts and municipalities are indicated in (**Figure 3.2**).

Mpumalanga province is well known for mining activities and it is the largest coal producing province, accounting for 80% of the coal production in South Africa (South Africa.info, 2015). Mpumalanga is the home to three major Eskom power stations that supply electricity. The production of coal in the province comes with the high risk of air, land and water pollution, a situation which is risky to pig health as it causes respiratory diseases. Most of the mining activities take place in the Highveld whilst the lowveld is more particular with agricultural activities. Environmental pollution was reported as the main source of ill health (respiratory diseases) in the Highveld of Mpumalanga (Zwi *et al.*, 1991). About 68% of the total of the province is used for agricultural purposes (South Africa info, 2015).

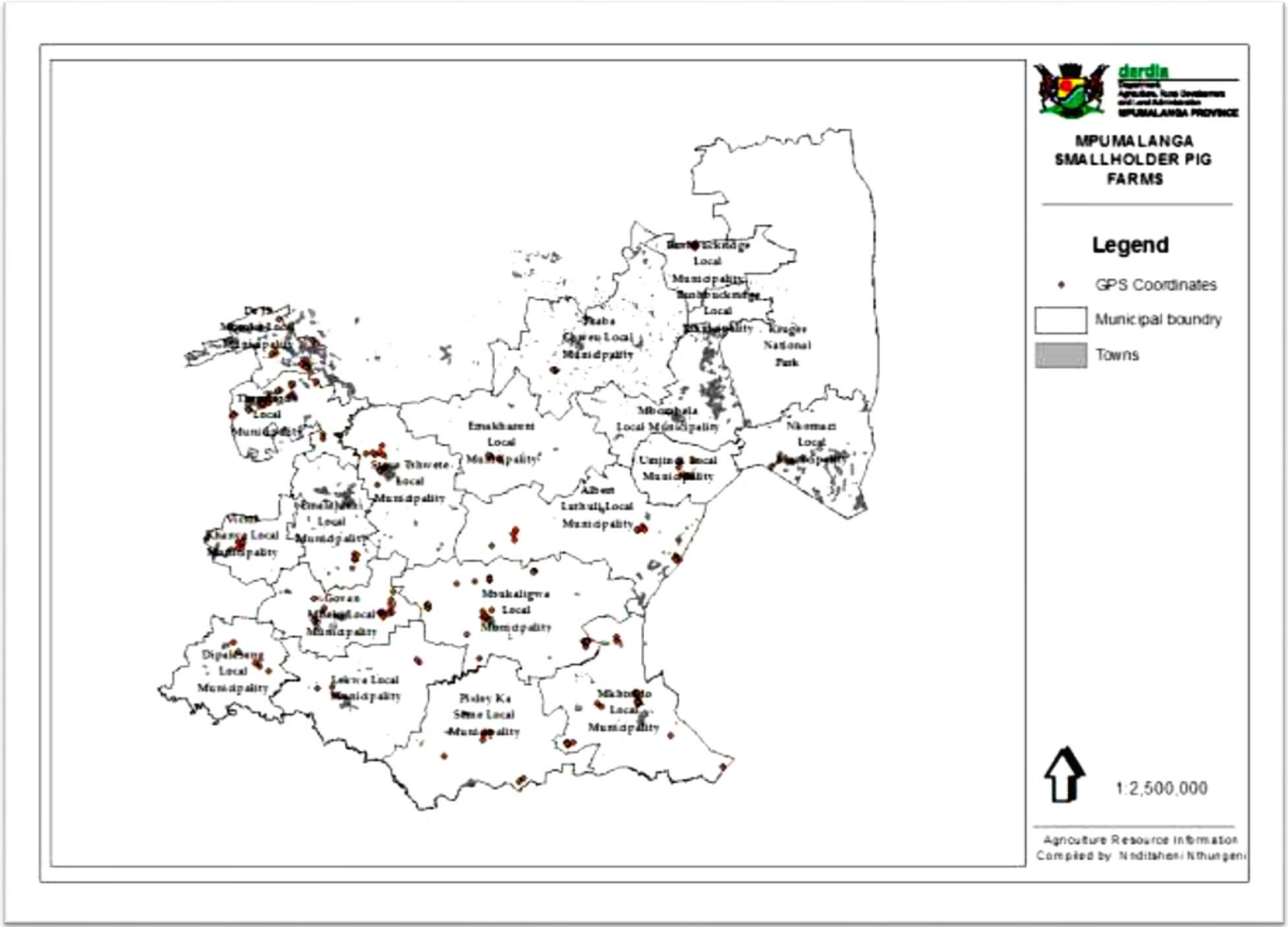


Figure 3.1. Map indicating the locations where data was collected

Figure 3.2.Three agro-ecological zones and local municipalities in Mpumalanga province

3.1.2 Brief description on the agro-ecological zones of Mpumalanga province

3.1.2.1 Climate in Mpumalanga province

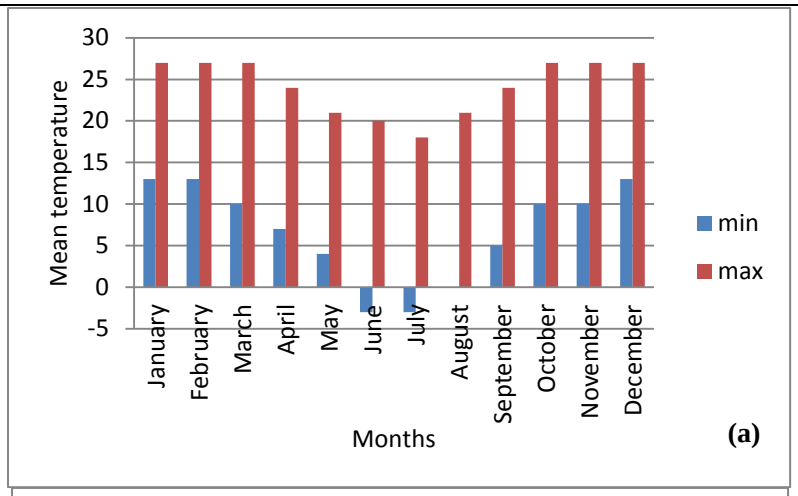
South Africa is classified as semi-arid due to the mean annual rainfall of about 450mm which is below the world average rainfall of about 850 mm per annum (Benhin, 2006). It has been zoned into eleven agro-ecological zones. The climate systems are caused by weather conditions from one season to another influenced by the elevation of the sea. The province has three different agro-ecological zones namely the Highveld, Midveld and Lowveld (**Figure 3.2**).The Highveld areas of Mpumalanga are characterised by cold frosty winters and on occasion snow on winter with moderate summer. The area produces high volume of grains such as grain (sorghum and maize) in summer seasons. The elevation varies from around 700 m above sea level at the river to over 900 m above sea level at the highest points (**Figure 3.3**). The climate in the lowveld is described as warm to hot, moist to wet summers and dry, mild to cool winters (Paterson, 2012).

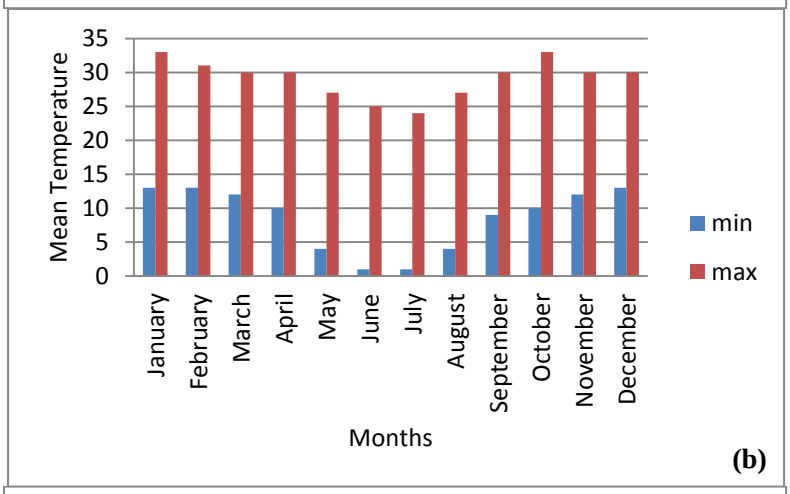
3.1.3 Research design and approach

The mixed method system was used (qualitative and quantitative). The reason for using mixed methods design was to capture the best of both qualitative and quantitative approaches (Creswell, 2003). The study was approved by the Ethical Committee of the College of Agriculture and Environmental Sciences, UNISA (CAES) with an Ethical approval number: 2013/CAES/140 before commencing with the study. Farmers were briefed on the objective of the study before data was collected.

3.1.4 Sample size and sample selection

Three agro-ecological zones were chosen because there is limited documented knowledge on the pig production systems, practices and constraints facing smallholders pig production in Mpumalanga province (**Figure 3.3**). The total number of the smallholders rearing pigs was also unknown and scanty information exists on the performance of the pigs in each agro-ecological zone.





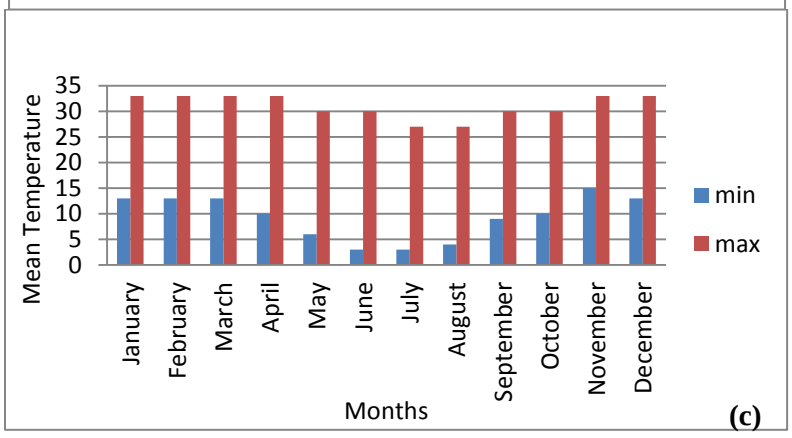


Figure 3.3: Mean environmental temperature in the (a) Highveld, (b) Midveld and (c) Lowveld of Mpumalanga, South Africa

Mpumalanga Province is divided agro-ecologically into the Highveld (H), the Midveld (M) and the Lowveld (L). Mean annual rainfall in the H, M & L is 601 to 900mm/annum, 501 to 750mm/annum & 601 – 1300mm/annum respectively. Averagely, the mean temperature is lower in the H compared with the M & L. (Acocks, 1988).

3.1.5 Sampling tools

A semi-structured questionnaire was used to collect information on demographics of the farmer, the herd structure, mortality percentages, management and husbandry practices. The questionnaire was administrated using face to face interview method. The reason for the use of face to face interviews was to ensure reliable, the correct response from the respondents, and take photographic documentation of the farming sites. Global positioning system (GPS) was used to collect the coordinates of the area where pigs were reared but in some areas co-ordinates were not taken due to limited numbers of GPS devices and in the situation where such positioning fell in geographically difficult-to-access locations (e.g mountain, river, and extensive road networks). The co-ordinates were recorded on the questionnaire (the latitude and longitude). Each questionnaire was given a unique questionnaire number.

3.1.6 Sampling procedures

A recent document targeted at smallholder farmers indicated that at least 5889 smallholder farms exist in Mpumalanga (DAFF, 2013; Figure 1). This number was utilized as the sample frame. The sample size was calculated for frequency using the formula:

Sample size n = [DEFF*Np (1-p)]/ [(d2/Z21-α/2*(N-1)+p*(1-p)]".

Where:

Population size (for finite population correction factor or fpc) (N): 5889

Hypothesized % frequency of outcome factor in the population (p): 50%+/-5

Confidence limits as % of 100 (absolute +/- %) (d): 5%

Design effect (for cluster surveys-DEFF): 1

A total of 361 farms were needed. Smallholder pig farms were randomly recruited continuously until no farm in that category can be identified again as farm of interest. A final list of 220 farmers were generated from the list provided by DARDLEA and the additions made through consultations with farmers, extension officers, animal health technicians and community leaders. All identified farmers were visited and data were collected through the use of a semi-structured pre-tested questionnaire. Direct observations were evaluated through a checklist and photographic documentation was obtained, where necessary.

The services of the extension officers and animal health technicians from the Mpumalanga Department of Agriculture, Rural Development, Land and Environmental Affairs (DARDLEA), who were previously trained in questionnaire administration, were utilised. A set of inclusion criteria was (a) ownership of ≥ 1 to ≤ 50 pigs; (b) Resident within the Province and active in the smallholder industry. Participants were identified using stratified randomly sampling method and the partial list of smallholder pig farmers supplied by DARDLEA. A total of 220 smallholder pig farmers were identified and sampled. The Highveld zone (n = 127) provides the highest number of respondents, followed by the midveld zone (n = 56) and lowveld zone (n = 37) was the least. Highveld covered most parts of the province and followed by the midveld (**Figure 3.2**). Agricultural advisors and Animal Health Technicians from DARDLEA were trained on questionnaire administration and the purpose of the study was explained to them. The leading researcher provided guidance and direction throughout the whole period of data collection.

The prepared semi-structured questionnaire was initially pre-tested among 10 pig farmers in Msukaligwa municipality in the Highveld to check for clarity and consistencies; and was adjusted appropriately to meet the need for this sampling. For the primary research, questionnaire was collected during farm and house visits. Although, the questionnaire was prepared in English, it was administered using native home languages (Zulu, IsiNdebele, Shangaan and Isiswati). The direct observation of the herd and facilities were done, and photographic documentation was acquired where necessary. Prior to photography, permission was obtained from the owner. The smallholder pig farmers were grouped based on the region where the farm is based namely Highveld, midveld and lowveld. The recorded coordinates were used to generate the map, which indicate the areas where data was collected. The main aim was to indicate the areas which are active in pig rearing in the Mpumalanga province (**Figure 3.1**).

3.1.7 Data management and analysis

All answers were recorded in English and entered into Microsoft Excel2007® spreadsheet. Filtered data was analysed using Stata v9 (Statacorp., Texas, USA) and Excel2007®. Outputs were generated in frequency tables for farmers, herd-related variables and hypothesis was tested using appropriate analytical methods (descriptive and correlation analyses). The proportion of pre-weaning and post-weaning mortality rates and causes of mortality were generated in figures. Associations between agricultural training, government material or financial assistance and thirteen herd and farmer-related variables were analysed using multivariable logistic regression model.

Furthermore, to determine associations, all data were reentered as 1 = yes and 0 = no and coded correctly for the Stata program. Using Chi-square test, outputs were generated to associate certain variables and preferred methods including markets, market determinants, treatment methods for sick pigs, feed preference, body conditions of the sows and age at weaning.

To integrate economic analyses, a partial budgeting and return on the investment (ROI) model has developed in Microsoft Excel 2007® spreadsheet. Outcomes from the data obtained including details from the field and published materials were utilized to develop and validate the model. Economic feasibility and viability of a 10-sow unit were tested for a three-year farm operation. Details of the inputs and outputs are available as appendix at the end of this dissertation. The sensitivity analyses were tested by varying some parameters including the reduction in feed price, removal of farmer's remuneration, transport cost and reduction of pre-weaning deaths. Outputs were generated in tables and graphs and the model is freely available in excel format for the use of smallholder farmers and development partners.

CHAPTER 4.0 RESULTS

4.1. The demographic profile of farmers who participated in the study in Mpumalanga

Significantly more male respondents were engaged in small-scale pig farming than female in the study areas and more than half of the respondents (≈ 54%) among the smallholder pig farmers were older than 50 years (**Table 4.1**). A total of 78.7% were at least 41 years and above. In addition, the huge majority of the smallholder pig farmers were the previously disadvantaged black South Africans (98.6%) and over three-quarters of all respondent were classified as being poor to just below average (**Table 4.1**; $P< 0.01$). A minority of the farmers (< 10%) had tertiary education and only 2.7% stayed in the urban center while 97.3% are rural or peri-urban. Family sizes differed significantly among the respondents (**Table 4.1**; $P< 0.01$), and only 19.6% and 33% of all respondents have received any form of agricultural training and financial or inputs assistance respectively (**Table 4.1**).

4.2. The demographic profile of farmers who participated: comparing three agro-ecological zones in Mpumalanga

In three agro-ecological zones, male respondents were majority in highveld and midveld whilst lowveld zone was dominated by African female (58.8%). A majority of farmers (≈ 89.3%) in midveld reported to be poor to just below average and about 76.8% did not have formal education. The pig farming in lowveld and midveld was practiced in the rural areas 91.9% and 87.5% respectively, whilst half of the respondents in highveld practiced pig farming in peri-urban. All the agro-ecological zones showed to attracts pig farmers with large household size (>6) in all the agro-ecological zones (**Table 4.1**, $P<0.0001$). It was also revealed that more than three-quarter of smallholder pig farmers in three agro-ecological zones of Mpumalanga had not received any agricultural training.

Table **4.1: Farmers-related variables among the survey small-scale pig farmers, Mpumalanga (*n* = 220)**

Variables	Descriptors	Highveld (*n*=127) (%)	Lowveld (*n*=37) (%)	Midveld (*n*=56) (%)	Mpumalanga (*n* = 220) % ($CI_{95\%}$)	P-value
Gender	Male	73.2 (65.4; 81.0)	43.2 (26.5; 60.0)	55.4 (41.9; 68.8)	63.6 (57.2; 70.0)[a]	< 0.0001
	Female	26.8 (19.0; 34.6)	56.8 (40.0; 73.5)	44.6 (31.2; 58.1)	36.4 (30.0; 42.8)	
Age	<20 years	1.6 (-0.62; 3.77)	0	0	0.9 (-0.4; 2.2)	< 0.01
	21-30 years	5.5 (1.5; 9.5)	5.4 (-0.2; 13.0)	12.5 (3.6; 21.4)	7.3 (3.8; 10.7)[e]	
	31-40 years	14.2 (8.0; 20.3)	16.2 (3.8; 28.7)	8.9 (1.2; 16.6)	13.2 (8.7; 17.7)[d]	
	41-50 years	20.5 (13.4; 27.6)	35.1 (19.0; 51.3)	26.8 (14.8; 38.8)	24.6 (18.8; 30.3)[c]	
	>50 years	58.3 (49.6; 70.0)	43.2 (26.5; 60.0)	51.8 (38.3; 65.3)	54.1 (47.5; 60.7)[b]	
Race	Black	97.6(95.0; 100)	100.0	100.0	98.6 (97.1; 100.2)[a]	< 0.0001
	Coloured	0.8 (-0.77; 2.3)	0	0	0.5 (-0.4; 0.1)	
	White	1.57 (-0.6; 3.8)	0	0	0.9 (-0.4; 21.7)	
Economic status	Poor	48.0 (39.2; 56.8)	59.5 (42.9; 76.1)	60.7 (47.5; 73.9)	53.2 (46.5;59.8)[b]	< 0.01
	Just below average	25.2 (17.5; 32.9)	18.9 (5.7; 32.2)	28.6 (16.4; 40.8)	25.0 (19.2; 30.8)[c]	
	Average	25.2 (17.5; 32.9)	21.6 (7.7; 35.5)	10.7 (2.4; 19.1)	20.9 (15.5; 26.3)[c]	
	Above average	1.6 (-0.6; 3.8)	0	0	0.9 (-0.4; 2.2)	
Educational qualification	No formal schooling	18.1 (11.3; 24.9)	13.5 (2.0; 25.1)	21.4 (10.3; 32.5)	18.2 (13.1; 23.3)	< 0.01
	Grade 1-11	52.8 (44.0; 61.6)	56.8 (40.0; 73.5)	55.4 (41.9; 68.8)	54.1 (47.5; 60.7)[b]	
	Grade 12	22.1 (14.7; 29.4)	16.2 (3.8; 28.7)	10.7 (2.4; 19.1)	18.2 (13.1; 23.3)	
	Post-matric	7.1 (2.6; 11.6)	13.5 (2.0; 25.1)	1.3 (3.6; 21.4)	9.6 (5.6; 13.5)	
Location	Rural	46.5 (37.7; 55.2)	91.9 (82.7; 101.1)	87.5 (78.6; 96.4)	64.6 (58.2; 70.9)[b]	< 0.01
	Urban	3.9 (0.5; 7.4)	0	1.8 (-1.8; 5.4)	2.7 (0.6; 4.9)	
	Peri-urban	49.6 (40.8; 58.4)	8.1 (-1.1; 17.3)	10.7 (2.4; 19.1)	32.7 (26.5; 39.0)[c]	
Household size	1	1.6 (-0.6; 3.8)	0	1.8 (-1.8; 5.4)	1.4 (-0.2; 2.9)	< 0.01
	2	9.5 (4.3; 14.6)	8.1 (-1.1; 17.3)	5.4 (-0.7; 11.4)	8.2 (4.5; 11.8)	
	3-5	44.9 (36.1; 53.7)	37.8(21.4; 54.2)	32.1 (19.5; 44.8)	40.5 (33.9; 47.0)[b]	
	6-8	37.0 (28.5; 45.5)	40.5 (23.9; 57.1)	48.2 (34.7; 61.7)	40.5 (33.9; 47.0)[b]	
	>8	7.1 (2.3; 11.6)	13.5 (2.0; 25.1)	12.5 (3.6; 21.4)	9.6 (5.6; 13.5)	
Received agricultural training	No	77.8 (70.4; 85.1)	78.4 (64.5; 92.3)	87.5 (78.6; 96.4)	80.4 (75.1; 85.7)[a]	< 0.0001
	Yes	22.2 (14.9; 29.6)	21.6 (7.7; 35.5)	12.5 (3.6; 21.4)	19.6 (14.3; 24.9)	
Received financial assistance/inputs	No	67.5 (59.2; 75.8)	73.0 (58.0; 89.0)	62.5 (49.4; 75.6)	67.1 (60.9;73.4)[a]	< 0.0001
	Yes	32.5 (24.2; 40.8)	27.0 (12.0; 42.0)	37.5 (24.4; 50.6)	32.9 (26.6; 39.2)	

Significant differences existed between or among the descriptors in each variables analysed. [a] Significant at < 0.0001 and [b,c,d] and [e] significant at < 0.01

4.3. Breeds of pigs reared and the animal husbandry in Mpumalanga province

In terms of the breeds kept in the area, approximately 89% of the farmers used mixed breeds of exotic pigs (primarily Large White-Landrace crosses), and majority (87.3%) of farmers had between 1 – 10sows in their herds (**Table 4.2**; $p< 0.01$). In terms of animal husbandry, 83.3% of the farmers practiced the risky behaviour of using auction-sourced boars, free-range boars or untested boars from neighbours and relatives ($p< 0.01$). This practice has implications for disease spread (**Table 2**). Very few (13.6%) of the respondents introduced the sows on oestrus to boars according to standard practice (1 – 3 days) while 30% kept the sows in the boar house for upward of 1 months (**Table 2**) while the remainder kept sow and boar for more than a month.

In addition, whereas 25% practiced free range system, the remaining 75% used the intensive or semi-intensive management principles (**Table 4.2**). A total of 99.5% of the respondents fed their pigs once, twice or thrice while 0.5% feeds ad lib or not at all ($p< 0.0001$). Eighty three percent (83%) did not practice vaccination and 90% did not keep records. The numbers of farrowing per sow per year differed significantly amongst the respondents and 96% did not weigh their pigs before sale (**Table 4.2**).

Approximately half (50%) of all pre-weaning mortalities were within the acceptable range while similar percentages significantly exceeded the range with certain farms having values of above 50% pre-weaning mortality rates (**Figure 4.1a**). Similarly, the majority (90%) of the reported post-weaning mortalities were within the acceptable range of 1-5% (**Figure 4.1b**). Lowveld had significantly higher abnormal mortality patterns compared with the Highveld and the Midveld regions (**Figures 4.1a &1b**). The leading causes of pre-weaning mortalities were piglets born weak & crushing of piglets by sow and overlay = 46%, neonatal diseases including diarrhea = 27.0%, poor management knowledge = 19.4% and malnutrition for the piglets = 15.6% (**Table 4.3**).

Table 4.2: Herd-related variables among the survey small-scale pig farmers, Mpumalanga (*n* = 220)

Variables	Descriptors	Highveld (*n*=127) (%)	Lowveld (*n*=37) (%)	Midveld (*n*=56) (%)	Mpumalanga (%) $CI_{95\%}$	P-value
Type of breed kept	Kolbroek	4.7 (1.0; 8.5)	0	7.1 (0.2; 14.1)	4.6 (1.8; 7.3)	< 0.01
	Exotic and their crosses	86.6 (80.6; 92.6)	94.6 (87.0; 102.3)	91.1 (83.4; 98.8)	89.1 (84.9; 93.2)[b]	
	Mix of Kolbroek and exotic	8.7 (3.7; 13.6)	5.4 (-2.2; 13.0)	1.8 (-1.8; 5.4)	6.1 (3.1; 9.6)	
No of sow in the herd	No breeding	1.6 (-0.6; 3.8)	0	0	0.9 (-0.4; 2.2)	<0.01
	1 – 10 sows	85.8 (79.7; 92.0)	81.1 (67.8; 94.3)	94.6 (88.6; 100.7)	87.3 (82.8; 91.7)[b]	
	11 – 20 sows	7.9 (3.1; 12.6)	8.1 (-1.1; 17.3)	3.6 (-1.4; 8.6)	6.8 (3.5; 10.2)	
	>20 sows	4.7 (1.0; 8.5)	10.8 (0.3; 21.3)	1.8 (-1.8; 5.4)	5 (2.1; 7.9)	
Boar source	Auction	11.8 (6.1; 17.5)	2.7	8.9 (1.2; 16.6)	9.6 (5.6; 13.5)	<0.01
	Buy young and raise, select from own boar	15.0 (8.7; 21.2)	10.8 (-2.8; 8.2)	10.7 (2.4; 19.1)	13.2 (8.7; 17.7)	
	Free range	0	5.4 (0.3; 21.3)	1.8 (-1.8; 5.4)	1.4 (-0.2; 2.9)	
	Local project breeder	16.5 (10.0; 23.1)	27.0 (12.0; 42.0)	10.7 (2.4; 19.1)	16.8 (11.8; 21.8)	
	Neighbor, relative, mixed	56.6 (48.0; 65.4)	54.1 (37.2; 70.9)	67.9 (55.2; 80.5)	59.1 (52.5; 65.6)[b]	
Boar and sow stay together often	No	57.6 (48.8; 66.4)	81.1 (67.8; 94.3)	53.6 (40.1; 67.0)	60.6 (54.0; 67.1)[a]	<0.0001
	Yes	42.4 (33.6; 51.2)	18.9 (5.7; 32.2)	46.4 (33.0; 60.0)	39.5 (32.9; 46.0)	
Boar length of stay with sow during mating	1 – 3 days	14.8 (8.4; 21.1)	18.9 (5.7; 32.2)	7.3 (0.2; 14.4)	13.6 (8.9; 18.2)	<0.0001
	1 week – 1 month	32.0 (23.6; 40.4)	18.9 (5.7; 32.2)	32.7 (20.0; 45.5)	29.9 (23.7; 36.1)	
	2 months – 3 months	2.5 (-0.3; 5.2)	0	1.8 (-1.8; 5.5)	1.9 (0.4; 3.7)	
	Continuous	40.2 (31.3; 49.0)	16.2 (3.8; 28.7)	54.6 (41.0; 68.1)	39.7 (33.1; 46.3)[a]	
	Free range	9.8 (4.5; 15.2)	46.0 (29.1; 62.8)	3.6 (-1.5; 8.7)	14.5 (9.7; 19.2)	
	Artificial insemination	0.8 (-0.8; 2.4)	0	0	0.5 (0.5; 1.4)	
Housing type	Intensive	20.6 (13.5; 27.8)	8.1 (-1.1; 17.3)	19.6 (8.9; 30.4)	18.3 (13.1; 23.4)	<0.01
	Semi-intensive	57.9 (49.2; 66.7)	48.7 (31.8; 65.5)	58.93 (45.6; 72.2)	56.6 (50.0; 63.2)[b]	
	Free range	21.4 (14.2; 28.7)	43.2 (26.5; 60.0)	21.43 (10.3; 32.5)	25.1 (19.3; 30.9)	
Number of feeding per day	Nil	0	0	1.8 (-1.8; 5.5)	0.5 (-0.5; 1.4)	<0.01
	Once	28.8 (20.8; 36.8)	29.7 (14.3; 45.2)	20 (9.1; 30.9)	26.7 (20.9; 32.6)	
	Twice	64 (55.5; 72.5)	64.9 (48.7; 81.0)	72.7 (60.6; 84.9)	66.4 (60.0; 72.7)[b]	
	Thrice	6.4 (2.0; 10.8)	5.4 (-2.2; 13.0)	5.5 (-0.7; 11.7)	6.0 (2.8; 9.2)	
	Ad lib	0.8 (-0.8; 2.4)	0	0	0.45(-0.45; 1.4)	
Implement vaccination	No	80	86.49	87.5	83.0 (78.0; 88.05)[a]	<0.0001
	Yes	20	13.51	12.5	17.0 (12.0; 22.1)	

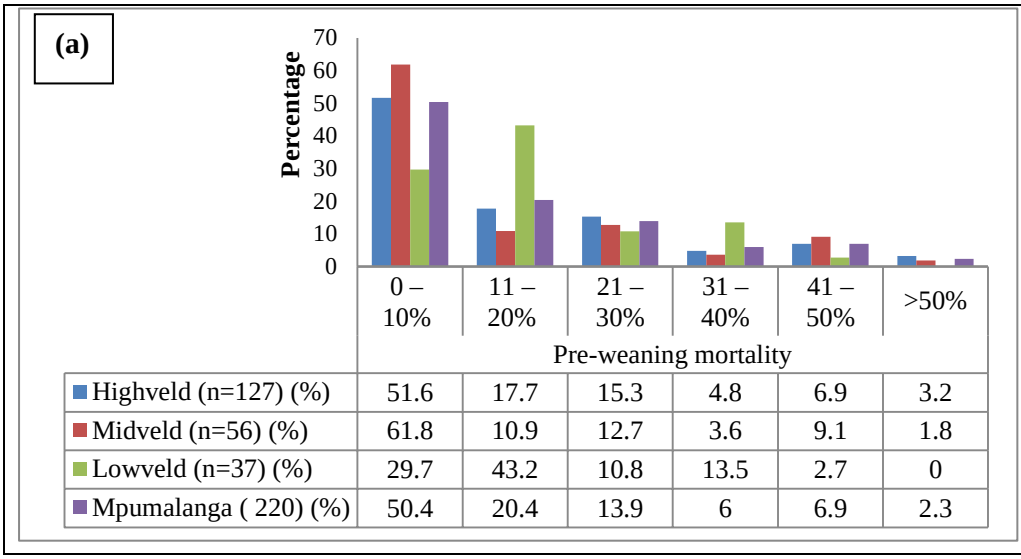
[a] Significant at < 0.0001 and [b] significant at < 0.01

Variables	Descriptors	Highveld (*n*=127) (%)	Lowveld (*n*=37) (%)	Midveld (*n*=56) (%)	Mpumalanga (%) $CI_{95\%}$	P-value
Record keeping	No	89.68	94.59	89.09	90.4 (86.4; 94.3)[a]	<0.0001
	Yes	10.32	5.41	10.91	9.6 (5.7; 13.6)	
Number of farrowing per year	1	13.71	8.11	12.5	12.4(8.0; 16.9)	<0.01
	2	79.03	81.08	76.79	78.8 (73.3; 84.3)[b]	
	Sometimes 3	7.26	10.81	10.71	8.76 (4.97; 12.55)	
Weighing done before sale	No	94.4	100	96.43	95.87 (93.32; 98.53)[a]	<0.0001
	Yes	5.6	0	3.57	4.13 (1.47;6.79)	

[a] Significant at < 0.0001 and [b] significant at < 0.01

Table 4.3: Major causes of piglet mortality reported among emerging small-scale pig farmers, Mpumalanga

Leading causes of neonatal mortality	Mpumalanga Province (*n* = 211)	Percentage	95% Confidence interval
Weak piglets/crushing	96	45.50	38.92; 52.24
Neonatal diseases	57	27.01	21.47; 33.38
Predation	21	9.95	6.60; 14.73
Cannibalism	9	4.27	2.26; 7.91
Malnutrition	33	15.64	11.36; 21.15
Lack of management knowledge	41	19.43	14.66; 25.30
Unknown causes	9	4.27	2.26; 7.91
Other reasons	13	6.16	3.64; 10.25



	0 – 10%	11 – 20%	21 – 30%	31 – 40%	41 – 50%	>50%
Highveld (n=127) (%)	51.6	17.7	15.3	4.8	6.9	3.2
Midveld (n=56) (%)	61.8	10.9	12.7	3.6	9.1	1.8
Lowveld (n=37) (%)	29.7	43.2	10.8	13.5	2.7	0
Mpumalanga (220) (%)	50.4	20.4	13.9	6	6.9	2.3

Figure 4.1a: Pre-weaning mortalities in three agro-ecological zones of Mpumalanga.

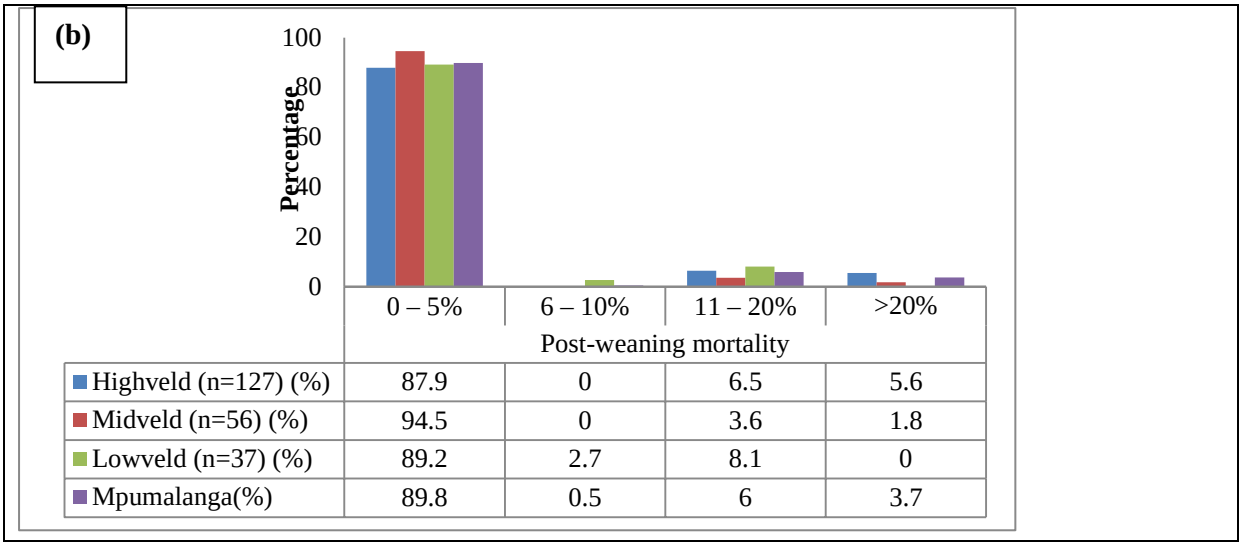


Figure 4.1b: Post-weaning mortalities in three agro-ecological zones of Mpumalanga

Table 4.4a: Association of receipt of government assistance with certain production variables

Variable	Odds Ratio	95% Conf. Interval	P values
Vaccination	3.83	1.65; 8.85	0.002
Farrowing/year	3.50	1.57; 7.81	0.002
Housing types	0.48	0.29; 0.81	0.0006
Economic status	1.78	1.21; 2.62	0.004

χ^2 = 51.20; Goodness of fit (GOF) Prob> χ^2 =0.98; Akaike information criterion (AIC) = 232.37

Table 4.4b: Association of training with certain production variables

Variable	Odds Ratio	95% Conf. Interval	P values
Ecological zones	0.58	0.36; 0.96	0.03
Farrowing/year	4.05	1.56; 10.51	0.004
Received assistance	10.35	4.50; 23.84	<0.0001

χ^2 = 58.54; Goodness of fit (GOF) Prob> χ^2 =0.17; Akaike information criterion (AIC) = 165.52

Using the logistic regression models, the receipt of agricultural assistance (financial/inputs) from government positively influence vaccination (OR = 3.8; p = 0.002), farrowing per year (OR = 3.5; p = 0.002) and economic statuses of the farmers (OR = 1.8; p = 0.004); however the odds of association between the animal housing types and receipt of government assistance was 0.5 (p = 0.0006; Goodness of fit Probability > χ^2 =0.98; **Table 4.4a**).

The model for the odds of association for agricultural training and other variables did not fit well since the Goodness of fit probability > χ^2 =0.17. However, there was a very good odds of associations between such training and receipt of government assistance (OR = 10.4) and farrowing/sow/year (OR = 4.1; **Table 4.4b**).

4.4. Breeds of pigs reared and the animal husbandry: comparing three agro-ecological zones in Mpumalanga province

Using the descriptive statistics, lowveld (94.6%), midveld (91.1%) and highveld (86.6%) reared exotic and their crosses (**Table 4.2**, $p<0.01$). Approximately three-quarters of the respondents in all three agro-ecological zones kept between 1 – 10 sows and lowveld zone had the highest responds of farmers amongst others with >20 (≈10.8%) sows in their herd. In terms of the boar source used for breeding, more than half of each zone used untested and potentially risky boars from neighbors, relatives, select from own herd, free range and auction. Only few used genetically approved boars from local project breeders including lowveld (27%), highveld (16.5%) and midveld (10.7%). In addition, midveld had the majority (67.9%) of farmers who did not kept breeding boars but depended on their neighbors and relatives for boars. Many farmers in lowveld (81.1%) separated boar and sow after breeding, whilst midveld (46.4%) kept the sow and boar continuously. The length of stay during mating was various in different zones, midveld and highveld practiced continuous method (leaving sow and boar throughout) 54.6% and 40.2% respectively, while some of respondents (32%) in the same regions leave the boar and sow for about one week to four weeks (**Table 4.2**, $p<0.0001$). The highveld (0.8%) was the only region with farmers who practiced the artificial insemination (AI).

Figure 4.2: Housing systems in smallholder pig farming in Mpumalanga **(Source: Munzhelele P, 2015)**

Three housing system was reported in this study, majority in all three regions used semi-intensive system (**Figure 4.2**) and lowveld had many farmers who used free range method (43.2%). Very few (1.8%) in midveld reported not to feed the pigs at all and only 0.8% of the participants in highveld region fed ad lib. More than 80% of all regions did not implement vaccination or kept records of the pigs. Significantly, sows farrowed twice in a year even though others reported once (13.7%) in the highveld. It was also found that respondents in lowveld did not weigh the pigs at all before marketing whilst few in highveld and midveld respondents weighed before marketing 5.6% and 3.57% consecutive.

4.5. Descriptive statistics on profit and market related variables

In approximately 41% of the farms surveyed, it was confirmed that the sows farrow 11 piglets and above; and over 58% farrowed ≤ 10. Only about 19% weaned at 1 month (industry standard) and only 11 % depend on commercial feed completely (**Table 4.5**). The majority of the farmers mix commercial feed with swills (41.6%) or feed swill and leftovers alone (47%) and about 69% will result to self-medication, allowed the animal to die or send to the slaughter any sick animal (**Table 4.5**). Only 27% sold their porkers at less than 6 months whereas the majority (73%) markets their pigs above 7 months. Less than 10% of all sows are in adequate body condition (at least a score of 3). The prevailing local and market price are the main determinant for marketing pigs and incomes arising from the sale are used mainly in the home front or to maintain the remaining pigs (**Table 4.5**).

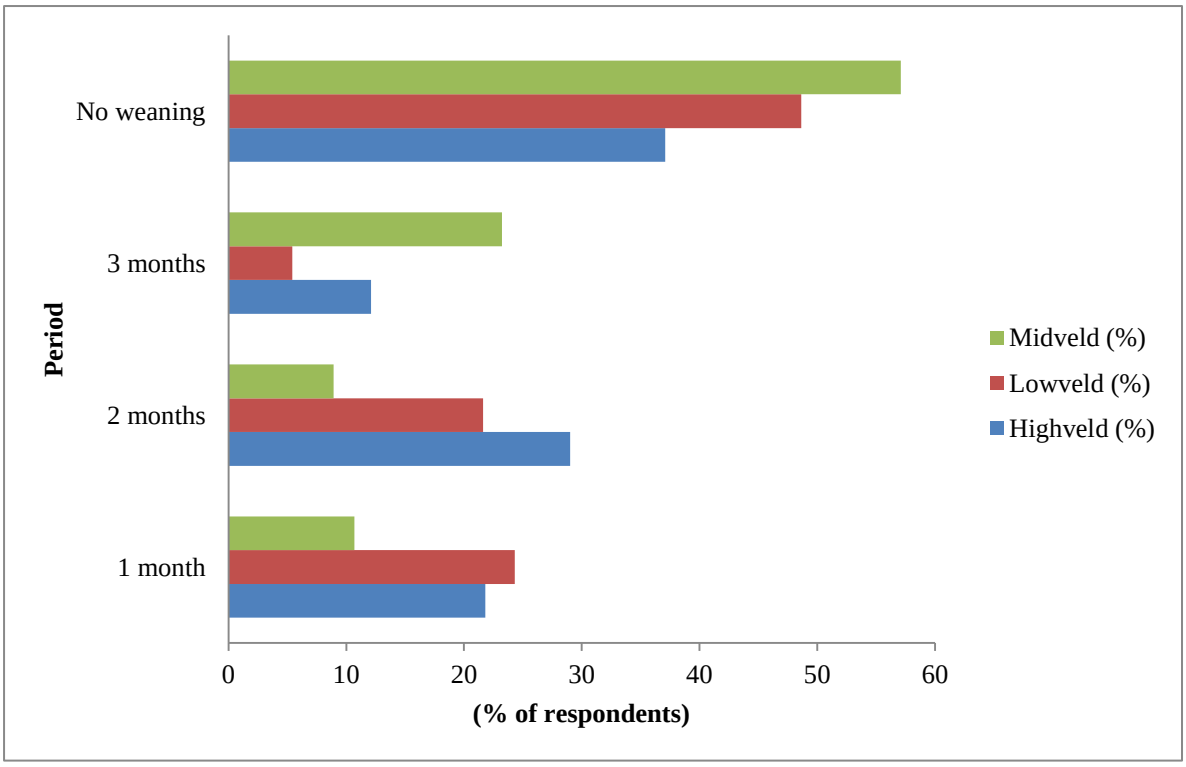


Figure 4.3: The comparison of weaning period in three agro-ecological zones

Comparing three agro-ecological zones in Mpumalanga province, midveld showed majority of respondents (57.1%) who practiced poor management of not weaning the piglets, followed by lowveld (48.7%). Highveld had majority respondents (50.8%) weaning piglets between one month and two months (**Figure 4.3**).

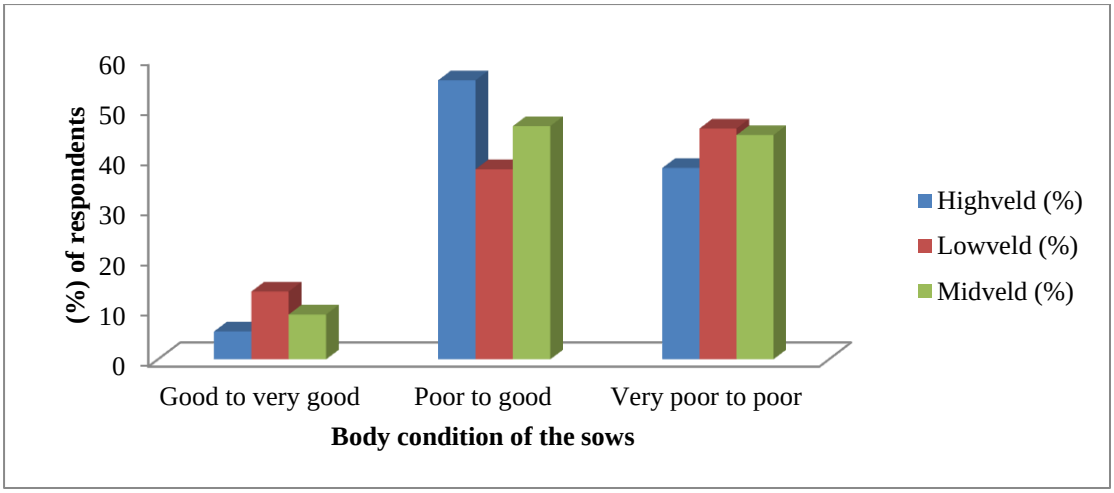


Figure 4.4: The body condition of the sows in three agro-ecological zones

Figure 4.5: The body condition of the sows in smallholder pig farming of Mpumalanga **(Source: Munzhelele P, 2015)**

Many (44.6%) sows in lowveld were observed to be very poor to poor body condition whist the good to obese were observed in lowveld zone (16.2%). Midveld had none respond with very good to obese and had 91.07% of very poor to good body condition of the sows. The biggest zone, highveld had 93.66% very poor to good body condition of the sows.

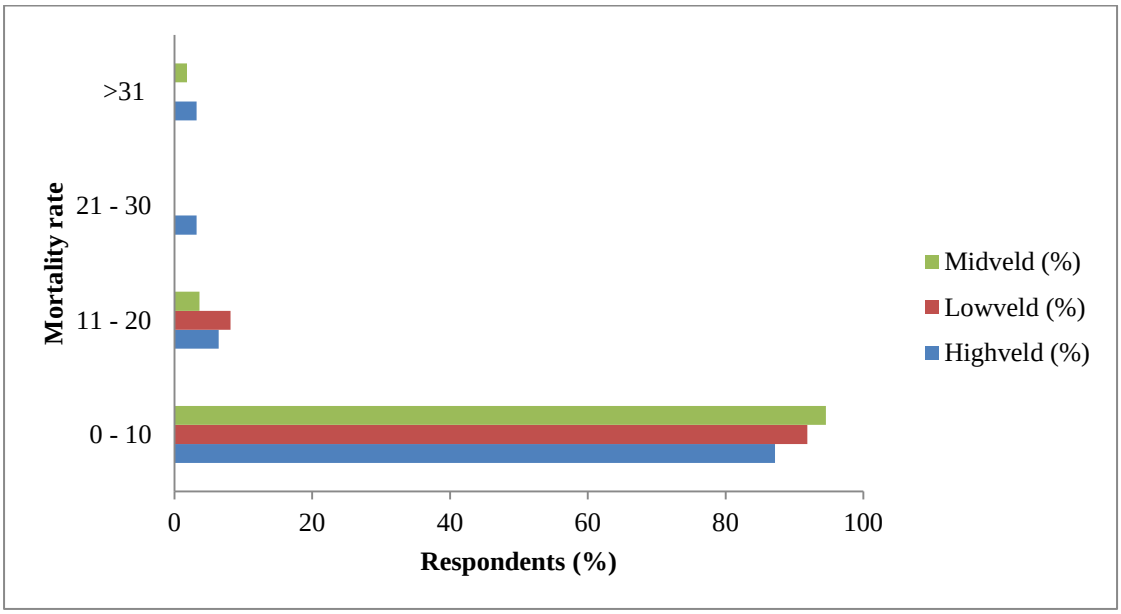


Figure 4.6: Pig mortality rates in three agro-ecological zones of Mpumalanga

Figure 4.6, illustrated that all the zones responds indicated that mortality was experienced at 0 – 10%, highveld (88.62%), lowveld (91.89%) and midveld (94.55%).

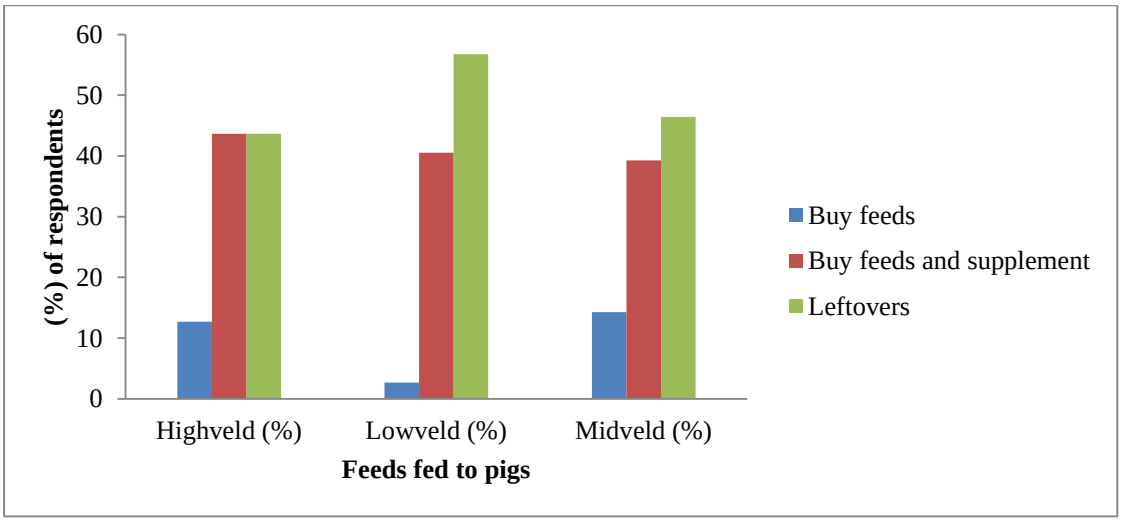


Figure 4.7: Feeds fed in three agro-ecological zones of Mpumalanga

Leftovers were the most fed in all three agro-ecological zones in smallholder pig farming in the Mpumalanga province. Lowveld (56.76%) fed mostly leftovers than other zones, followed by midveld (46.43%), whilst highveld buy feeds and also supplements with leftovers. Lowveld had had the few (2.70%) respondents who buy feeds to feed pigs (**Figure 4.7**).

Figure 4.8: Swills and water in smallholder pig farming in Mpumalanga
Source: (Munzhelele P, 2015)

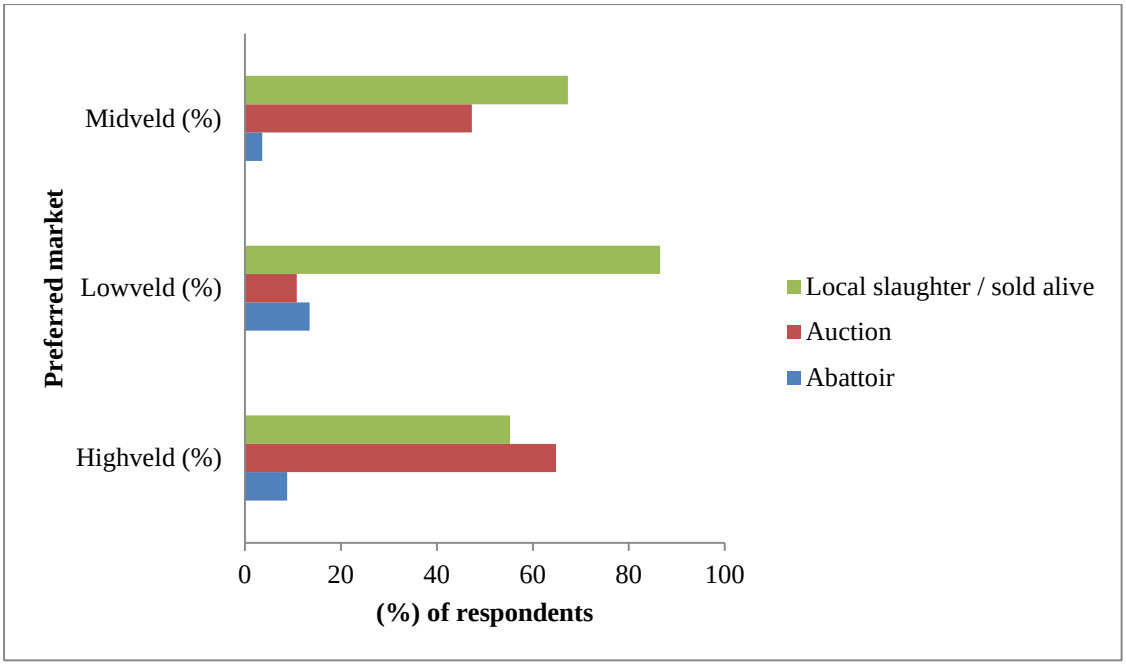


Figure 4.9: Market preference in the smallholder pig farmers in Mpumalanga province

The results show that smallholder pig farmers in lowveld (86.49%) and midveld (67.27%) zones preferred local slaughter / sold alive. Smallholder pig farmers in the Highveld region (64.8%) preferred to sell pigs at the auction. Abattoir market showed to attract few pig farmers in all agro-ecological zones with lowveld with many respondents (13.51%).

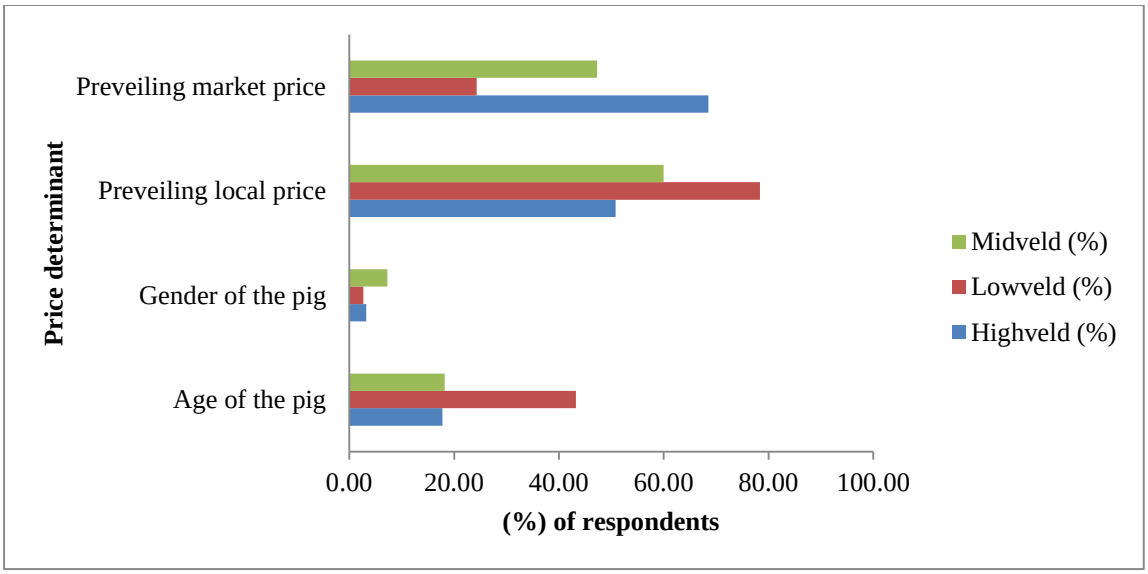


Figure 4.10: Price determinant of the **s**mallholder pig farms in three agro-ecological zones of Mpumalanga

Figure 4.11: Home slaughter facility in smallholder pig farming of Mpumalanga
(Source: Munzhelele P, 2015)

The prevailing local price was the most influenced price determinant in smallholder pig farming in Mpumalanga more especially in lowveld (78.38%) and midveld (60%) whilst prevailing market price was the most influencing factor in highveld (68.55%). Gender of the pig did not play a major role in all three agro-ecological zones and the age of the pig was mostly considered in lowveld (43.24%).

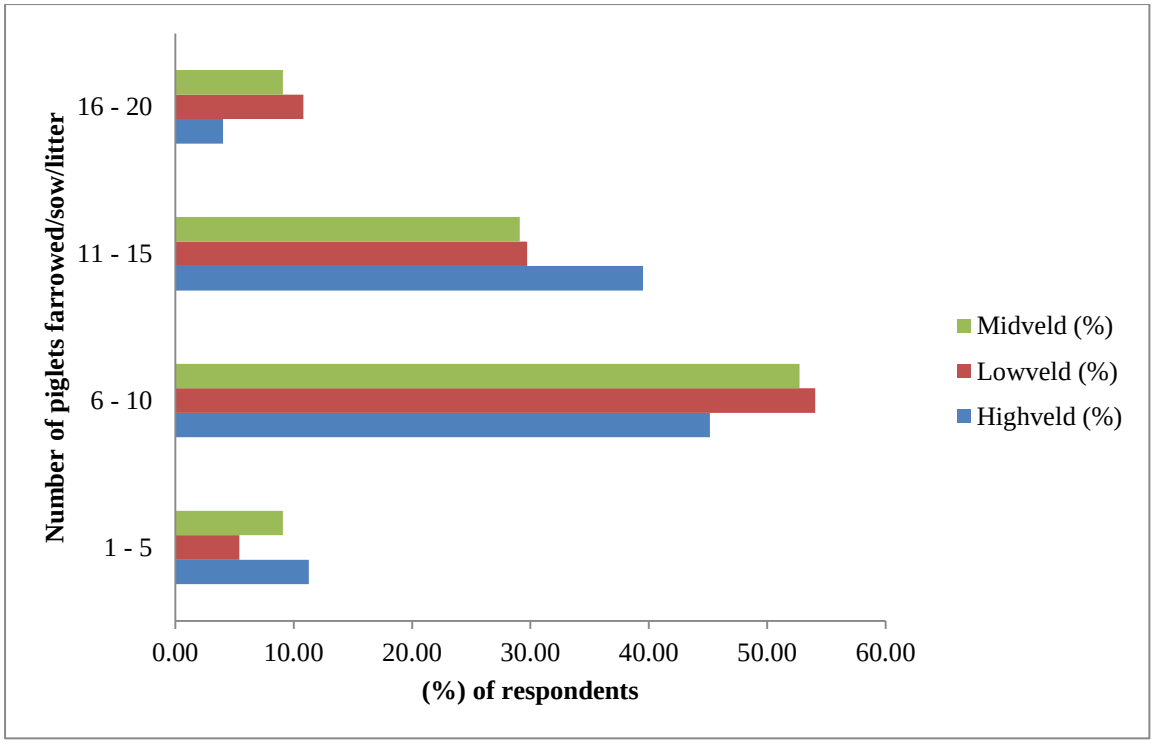


Figure 4.12: The average numbers of the piglets farrowed /sow/litter in smallholder of Mpumalanga

Lowveld (54.05%), midveld (52.73%) and highveld (45.16%) had a majority of respondents who reported six to 10 piglets /farrowed/sow/litter. About 11 - 20 piglets (43.55%) in the highveld and lowveld (40.54%) were farrowed /sow/litter.

Table 4.5: Profit and market-related variables of smallholder farmers, Mpumalanga

Variables	Descriptors	Mpumalanga $CI_{95\%}$	P- value
Market (*n* = 217)	Abattoir	8.3 (5.2; 12.8)	<0.0001
	Auction	51.2 (44.5; 57.7)[a]	
	Local slaughters/sold live	64.0 (57; 70.0)[a]	
Price determinant (*n* = 215)	Age of the pig	22.3 (17.3; 28.4)	<0.0001
	Gender of the pig	4.2 (2.1; 7.9)	
	Prevailing local price	57.2 (50.5; 63.6)[a]	
	Prevailing market price	55.8 (49.1; 62.3)[a]	
Uses of profit (*n* = 217)	Home groceries	64.5 (57.9; 70.6)[a]	<0.0001
	Education	30.4 (24.7: 36.8)	
	Maintenance of family	27.2 (21.7; 33.5)	
	Maintenance of pigs	66.0 (59.4; 71.9)[a]	
	Others	5.1 (2.8; 8.9)	
Age at which pigs are sold (*n* = 217)	Less than 6 months	26.7 (21.3; 33)	<0.0001
	7 months to 18 months	61.8 (55.1; 68.0)[a]	
	Above 19 months	11.5 (7.9; 16.5)	
What to do when pigs are sick? (*n*= 219)	Ethno vet preparations*	13.2 (9.3; 18.4)	<0.0001
	Self-medication**	33.8 (27.9; 40.3)[a]	
	Consult professionals	17.4 (12.9; 23.0)	
	Leave to die or slaughter	35.6 (29.6; 42.2)[a]	
Number farrowed/sow/litter (*n* = 216)	1 – 5	9.7 (5.7; 13.7)	<0.0001
	6 – 10	48.6 (41.9; 55.3)[a]	
	11 – 15	35.2 (28.8; 41.6)[a]	
	16 – 20	6.5 (3.2; 9.8)	
Feed fed to pigs (*n* = 219)	Buy feeds	11.41 (7.2; 15.7)	<0.0001
	Buy feeds and supplement	41.6 (35.0; 48.1)[a]	
	Leftovers	47.0 (40.4; 53.7)[a]	
Body condition of sows (*n* = 219)	Poor	41.1 (34.5; 47.7)[a]	<0.0001
	Good	50.2 (43.6; 56.9)[a]	
	Very good	7.8 (4.2; 11.3)	
	Obese	0.9 (-0.4; 2.2)	
Weaning age (*n*=217)	1 month	19.4 (14.1; 24.7)	<0.0001
	2 months	22.6 (17.0; 28.2)	
	3 months	13.8 (9.2; 18.5)	
	No weaning	44.2 (37.6; 50.9)[a]	

**Ethno veterinary preparations used by the smallholder farmers include Aloe, blue bar soap, potassium manganate, used engine oil, salt blue soap and feed, used vegetable oil; ** Self-medication include the abuse of antibiotics and use of other medications like ivermectin and others.* [a] Significant at < 0.0001

4.6. The Associations between different variance

Using the Chi square, the prevailing market price significantly influenced the preference for abattoirs ($\chi2 = 8.96$, $p < 0.005$), auctions ($\chi2 = 135.51$, $p < 0.0001$) and local slaughter slabs ($\chi2 = 72.71$, $p < 0.0001$) as a means of disposal of final products (**Table 4.6**). Similarly, the prevailing local price of product had an influence on sales at auctions ($\chi2 = 39.74$, $p < 0.0001$), and local slaughter slabs ($\chi2 = 114.39$, $p < 0.0001$). Age of pigs at sale slightly influenced the sale at auctions ($\chi2 = 6.11$, $p = 0.01$) but significantly influenced sales at local slaughter slabs ($\chi2 = 28.97$, $p < 0.0001$). There was a significant association between the use of ethno-veterinary preparations and sales at auctions ($\chi2 = 11.37$, $p = 0.001$), or at local slaughter slabs ($\chi2 = 7.30$, $p < 0.01$). Furthermore, farmers who self-medicated their pigs disposed-off their products in the auctions ($\chi2 = 6.87$, $p < 0.01$) or at the local slaughter slabs ($\chi2 = 11.35$, $p = 0.001$) (**Table 4.6**). Finally only the local slaughter slabs and the slaughter of sick animals have association ($\chi2 = 6.58$, $p = 0.01$).

Table 4.6: Association between preferred methods of marketing, market price determinants and type of treatment for sick animals

	Methods of marketing		
	Abattoir	**Auction**	**Local slaughter**
Market price determinants	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)
Age of pig	0.0001 (0.99)	6.11 (0.01)	28.97 (<0.0001)
Gender of pig	0.0979 (0.75)	3.15 (0.08)	2.76 (0.10)
Prevailing local price	4.73 (<0.05)	39.74 (<0.0001)	114.39 (<0.0001)
Prevailing market-related price	8.96 (<0.005)	135.51 (<0.0001)	72.72 (<0.0001)
Type of treatment for sick animals			
Ethno-veterinary preparations*	0.94 (0.33)	11.37 (0.001)	7.30 (<0.01)
Self-medication	2.21 (0.14)	6.87 (<0.01)	11.35 (0.001)
Consultation veterinary professional**	0.30 (0.58)	0.08 (0.36)	1.99 (0.16)
Slaughter the sick animal	1.51 (0.22)	0.92 (0.34)	6.58 (0.01)

p-values are indicated in parenthesis.
**Ethno-veterinary preparations were indicated in footnote to table 1 above. **Consult vets means consultation with private or government veterinarians including veterinary para-professionals.*

There were associations between the feeding of commercial rations solely and poor body conditions ($\chi 2 = 9.75$, $p < 0.005$) and poor-fairly good conditions ($\chi 2 = 5.46$, $p < 0.05$). Farmers who weaned their piglets at 1 months have their sows in very good body conditions comparatively ($\chi 2 = 8.55$, $p < 0.005$), while those who weaned at about 3 months have good-very good body conditions ($\chi 2 = 6.46$, $p = 0.01$) and those who did not wean at all have their sows in poor ($\chi 2 = 8.80$, $p < 0.005$) or good-very good conditions ($\chi 2 = 11.56$, $p= 0.001$) (**Table 4.7**). Similarly, there were associations between weaning at 1 month and feeding of commercial ration ($\chi 2 = 19.80$, $p < 0.0001$), mixing of commercial ration and swill ($\chi 2 = 11.47$, $p = 0.001$) and mixing of swill and household remnants alone ($\chi 2 = 10.62$, $p = 0.001$) (**Table 4.8**).

Table 4.7: Association between body condition scores, types of feed used and age at weaning

	Body conditions			
	Poor (≤ 2)	**Poor - Good (2.5-3)**	**Good - Very good (3-3.5)**	**Very good - Obese (3.5-4)**
Feed types	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)
Only commercial ration	9.75 (<0.005)	5.46 (<0.05)	2.29 (0.13)	2.99 (<0.10)
Commercial ration and swill	3.14 (<0.10)	1.82 (0.18)	0.55 (0.46)	1.81 (0.18)
Only swill and remnants	2.98 (<0.10)	1.17 (0.28)	0.44 (0.51)	1.74 (0.18)
Age at weaning				
1 month	3.27 (<0.10)	0.47 (0.49)	2.57 (0.11)	8.55 (0.003)
2 months	0.45 (0.50)	0.24 (0.63)	0.34 (0.56)	0.58 (0.45)
3 months	0.82 (0.36)	0.15 (0.69)	6.46 (0.01)	0.32 (0.57)
No weaning	8.80 (<0.005)	0.67 (0.42)	11.56 (0.001)	1.56 (0.21)

p-values are indicated in parenthesis.
**Swill refers to: Kitchen swills, restaurant swills, hospital swills, school swills, ripen fruits, cow milk, maize, vegetables*

Table 4.8: Association between types of feed used and weaning age

Age at weaning	Types of feed used		
	Only commercial ration	**Commercial ration and swill**	**Only swill and remnants**
	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)
1 month	19.78 (<0.0001)	11.47 (0.001)	10.62 (0.001)
2 months	0.64 (0.42)	0.07 (0.79)	0.17 (0.68)
3 months	2.22 (0.14)	0.51 (0.47)	0.68 (0.41)
No weaning	2.80 (0.09)	3.25 (<0.10)	3.13 (<0.10)

p-values are indicated in parenthesis.

Significant association existed between production of larger number of piglets and feeding of commercial ration ($\chi2 = 11.57$, $p = 0.001$). In contrast, the mixing of swill and commercial ration were associated with the production of low ($\chi2 = 17.25$, $p < 0.0001$) to medium level ($\chi2 = 23.11$, $p < 0.0001$) of piglets number per litter (**Table 4.9**). The feeding of swill only produced similar significant results (**Table 4.9**). Similarly, sows in poor body condition produced low level ($\chi2 = 6.37$, $p = 0.01$) to medium level of piglets per litter ($\chi2 = 5.44$, $p = 0.02$) (**Table 4.9**). Only sows in very good body conditions have association with large number of piglets per litters ($\chi2 = 7.77$, $p = 0.005$)

Table 4.9: Association between average number of piglets farrowed per sow per litter, types of feed used and body condition scores

Feed types	Average number of piglets farrowed per sow per litter			
	1-5 piglets	**6-10 piglets**	**11-15 piglets**	**≥ 16 piglets**
	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)	χ^2 (*p*-value)
Only commercial ration	0.08 (0.78)	2.80 (<0.10)	0.37 (0.54)	11.57 (0.001)
Commercial ration and swill	1.99 (0.16)	17.25 (<0.0001)	23.11 (<0.0001)	0.99 (0.32)
Only swill and remnants	1.08 (0.30)	19.51 (<0.0001)	21.31 (<0.0001)	0.87 (0.35)
Body conditions				
Poor (≤ 2)	6.37 (0.01)	4.88 (<0.05)	5.44 (<0.05)	3.09 (<0.10)
Poor - Good (2.5-3)	4.26 (<0.05)	0.89 (0.35)	3.94 (0.05)	0.35 (0.55)
Good - Very good (3-3.5)	0.36 (0.55)	1.63 (0.20)	0.16 (0.69)	1.22 (0.27)
Very good - Obese (3.5-4)	0.21 (0.64)	1.84 (0.18)	0.21 (0.64)	7.77 (0.005)

4.7. Economic models of smallholder pig farm

Using partial budgeting and return-on-investment (ROI) models, the 10-sow unit pig farm continues to utilize more cash (outflow) than the receipts that came in into the farm account. Feed (using commercial ration) accounted for at least 75% of the annual cash outflow at any one year (**Tables 4.10a-10c, Figure 4.13a**). With a 50% reduction in feed price through supplementation with swill and leftovers from the home, the model became economically viable towards the end of the third year of operation (**Figure 4.13b**). A 100% reduction in feed price through complete replacement with swill will however make the farm model to break even in the beginning of the second year of operation with subsequent profits (**Figure 4.13c**). with a complete removal of remuneration for the farmer over a three year project cycle, the farm was still economically unsustainable (**Figure 4.13d**) and similar results obtained with a 60% reduction in transport cost (**Figure 4.13e**) and improving the farm productivity through a 25% reduction in pre-weaning mortalities (**Figure 4.13f**).

Table 4.10a: Project Cash Flow Statement for a model 10 sow-unit, Mpumalanga, 2015

Model smallholder pig farm, Year 1 estimates														
Project Cash Flow Statement for a model 10 sow-unit, Mpumalanga, 2015														
Description	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**	**Source**
Opening bank balance	1,500	0	0	0	0	0	0	0	0	0	0	0	**1,500**	**Department of labour, 2015**
Project income (Invoiced amt)	0	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	17,061	17,061	17,061	**63,183**	**ABSA, 2015;Fasina et al., 2012; Munzhelele, Oguttu & Fasina (unpublished data)**
Loan	0						0						**0**	
Total Cash Inflow	**1,500**	**1,500**	**1,500**	**1,500**	**1,500**	**1,500**	**1,500**	**1,500**	**1,500**	**17,061**	**17,061**	**17,061**	**64,683**	
Once-off costs	**59,000**												**59,000**	
Building material	**30,000**												**30,000**	**Author's estimate**
10 Sows @ R2,500	**25,000**												**25,000**	**Auction price**
1 Boars @ R4,000	**4,000**												**4,000**	**Auction price**
Farmer's remuneration	0	0	0	0	0	0	0	0	0	1,000	1,000	1,000	**3,000**	**Opinion survey**
Accounting Fees	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
Bank Charges	0	100	100	100	100	100	100	100	100	100	100	100	**1,100**	**Author's estimate**
Disinfectants	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
Feed (48 tonnes/annum)	**0**	**2,996**	**2,996**	**2,996**	**2,996**	**11,833**	**29,882**	**29,882**	**29,882**	**29,882**	**29,882**	**29,882**	**203,109**	**Fasina et al., 2012; Fasina et al., 2015**
10 Sows + 1 Boar	0	2,996	2,996	2,996	2,996	2,996	2,996	2,996	2,996	2,996	2,996	2,996	**32,956**	**Roelofse, 2013; Authors' calculations**
Weaners	0					8,837	8,837	8,837	8,837	8,837	8,837	8,837	**61,859**	**Authors' calculations**
Growers, Porkers and Finishers	0						18,049	18,049	18,049	18,049	18,049	18,049	**108,294**	**Authors' calculations**
Breeders								0	0	0	0	0	**0**	
Others	0								0	0	0	0	**0**	
Labour costs	0	0	0	0	0	0	0	0	0	250	250	250	**750**	**Opinion survey**
Medicines and Vaccines	485	485	485	485	485	485	485	485	485	485	485	485	**5,820**	**Fasina et al., 2012**
Telephone	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
Transport	0	3,627								3,627	3,627	3,627	**14,508**	**Author's calculations**
Water and Electricity	0	450	450	450	450	450	450	450	450	450	450	450	**4,950**	**Author's estimate**
Miscellaneous expenses			1,279	1,279	1,279	1,279	1,279	1,279	1,279	1,279	1,279	1,279		
Loan Repayments	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Initiation fee	**0**												**0**	
Repayment - Capital & Interest										**0**	**0**	**0**	**0**	
Total Cash Outflow	**59,485**	**7,658**	**5,310**	**5,310**	**5,310**	**14,147**	**32,196**	**32,196**	**32,196**	**37,073**	**37,073**	**37,073**	**267,954**	

Table 4.10b: Project Cash Flow Statement for a model 10 sow-unit, Mpumalanga, 2016

Model smallholder pig farm, Year 2 estimates													
Project Cash Flow Statement for a model 10 sow-unit, Mpumalanga, 2016													
Description	**Jan**	**Feb**	**Mar**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
Opening bank balance	- 240,344	- 257,872	- 275,399	- 292,927	- 310,455	- 327,983	- 345,510	- 363,038	- 380,566	- 398,094	- 415,621	- 433,149	-4,040,959
Project income (Invoiced amt + monthly subsidy from salary)	18,151	18,151	18,151	18,151	18,151	18,151	18,151	18,151	18,151	18,151	18,151	18,151	217,812
XYZ loan													0
Total Cash Inflow	**- 222,193**	**- 239,721**	**- 257,248**	**- 274,776**	**- 292,304**	**- 309,832**	**- 327,359**	**- 344,887**	**- 362,415**	**- 379,943**	**- 397,470**	**- 414,998**	**-3,823,147**
Owner's remuneration	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	12,000
Accounting Fees	0	0	0	0	0	0	0	0	0	0	0	0	0
Bank Charges	100	100	100	100	100	100	100	100	100	100	100	100	1,200
Disinfectants	0	0	0	0	0	0	0	0	0	0	0	0	0
Feed	**31,974**	**31,974**	**31,974**	**31,974**	**31,974**	**31,974**	**31,974**	**31,974**	**31,974**	**31,974**	**31,974**	**31,974**	**383,685**
10 Sows + 1 Boar	3,206	3,206	3,206	3,206	3,206	3,206	3,206	3,206	3,206	3,206	3,206	3,206	38,469
Weaners	9,456	9,456	9,456	9,456	9,456	9,456	9,456	9,456	9,456	9,456	9,456	9,456	113,467
Growers, Porkers and Finishers	19,312	19,312	19,312	19,312	19,312	19,312	19,312	19,312	19,312	19,312	19,312	19,312	231,749
Breeders													0
Others													0
Labour costs	268	268	268	268	268	268	268	268	268	268	268	268	3,216
Medicines and Vaccines	519	519	519	519	519	519	519	519	519	519	519	519	6,228
Telephone													0
Transport	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	15,600
Water and Electricity	518	518	518	518	518	518	518	518	518	518	518	518	6,216
Loan Repayments	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0
Initiation fee													**0**
Repayment - Capital & Interest	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total Cash Outflow	**35,679**	**35,679**	**35,679**	**35,679**	**35,679**	**35,679**	**35,679**	**35,679**	**35,679**	**35,679**	**35,679**	**35,679**	**392,466**
Net Cash Flow	**- 257,872**	**- 275,399**	**- 292,927**	**- 310,455**	**- 327,983**	**- 345,510**	**- 363,038**	**- 380,566**	**- 398,094**	**- 415,621**	**- 433,149**	**- 450,677**	**-4,251,292**

Table 4.10c: Project Cash Flow Statement for a model 10 sow-unit, Mpumalanga, 2017

Model smallholder pig farm, Year 3 estimates													
Project Cash Flow Statement for a model 10 sow-unit, Mpumalanga, 2017													
Description	**Jan**	**Feb**	**Mar**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
Opening bank balance	-450,677	- 469,512	- 488,347	- 507,182	- 526,017	- 544,852	- 563,687	- 582,522	- 601,357	- 610,074	- 618,791	- 627,508	- 6,590,523
Project income (Invoiced amt)	19,316	19,316	19,316	19,316	19,316	19,316	19,316	19,316	19,316	19,316	19,316	19,316	231,792
XYZ loan													0
Total Cash Inflow	**-431,361**	**- 450,196**	**- 469,031**	**- 487,866**	**- 506,701**	**- 525,536**	**- 544,371**	**- 563,206**	**- 582,041**	**- 590,758**	**- 599,475**	**- 608,192**	**- 6,358,731**
Owner's remuneration	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	12,000
Accounting Fees	0	0	0	0	0	0	0	0	0	0	0	0	0
Bank Charges	110	110	110	110	110	110	110	110	110	110	110	110	1,320
Disinfectants	0	0	0	0	0	0	0	0	0	0	0	0	0
Feed	**34,212**	**34,212**	**34,212**	**34,212**	**34,212**	**34,212**	**34,212**	**34,212**	**24,094**	**24,094**	**24,094**	**24,094**	
10 Sows + 1 Boar	3,430	3,430	3,430	3,430	3,430	3,430	3,430	3,430	3,430	3,430	3,430	3,430	41,165
Weaners	10,118	10,118	10,118	10,118	10,118	10,118	10,118	10,118					80,943
Growers, Porkers and Finishers	20,664	20,664	20,664	20,664	20,664	20,664	20,664	20,664	20,664	20,664	20,664	20,664	247,966
Breeders													0
Others													0
Labour costs	287	287	287	287	287	287	287	287	287	287	287	287	3,441
Medicines and Vaccines	555	555	555	555	555	555	555	555	555	555	555	555	6,664
Telephone	0	0	0	0	0	0	0	0	0	0	0	0	0
Transport	1,391	1,391	1,391	1,391	1,391	1,391	1,391	1,391	1,391	1,391	1,391	1,391	16,692
Water and Electricity	596	596	596	596	596	596	596	596	596	596	596	596	7,148
GEP Repayments	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0
Initiation fee													**0**
Repayment - Capital & Interest	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total Cash Outflow	**38,151**	**38,151**	**38,151**	**38,151**	**38,151**	**38,151**	**38,151**	**38,151**	**28,033**	**28,033**	**28,033**	**28,033**	**389,307**
Net Cash Flow	**-469,512**	**488,347**	**507,182**	**526,017**	**544,852**	**563,687**	**582,522**	**601,357**	**610,074**	**618,791**	**627,508**	**636,225**	**6,776,071**

Figure 4.13a-f: Economic evaluation and sensitivity analyses of a 10-sow-unit pig production, South Africa.

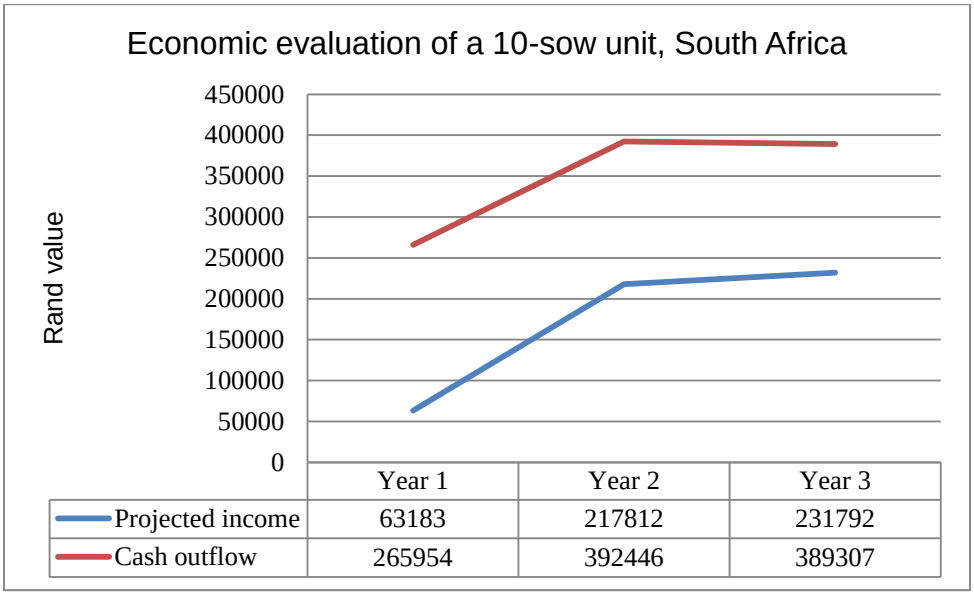


Figure 4.13a: Economic evaluation of a 10-sow unit, South Africa

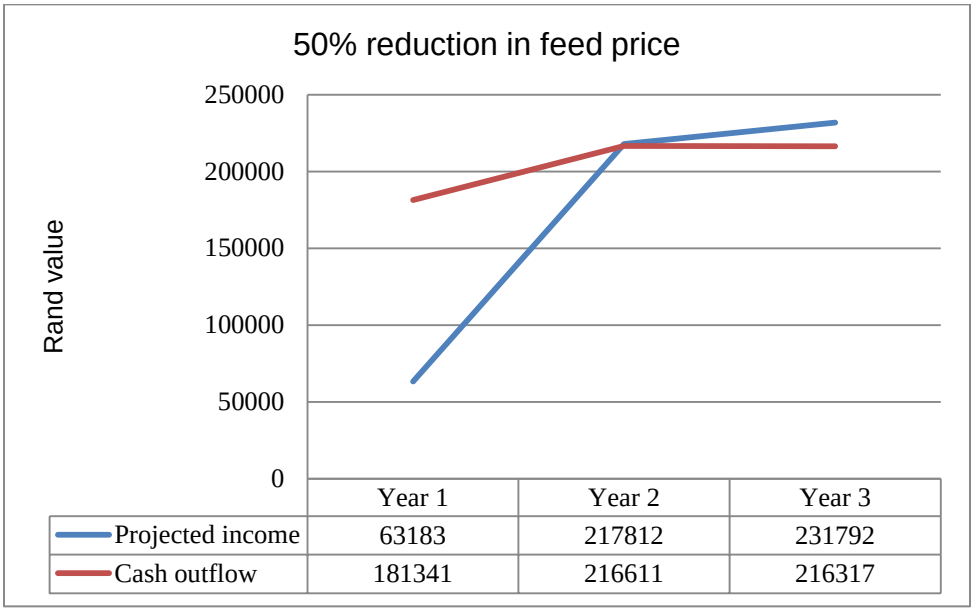


Figure 4.13b: Fifty percent (50%) reduction in commercial feed price

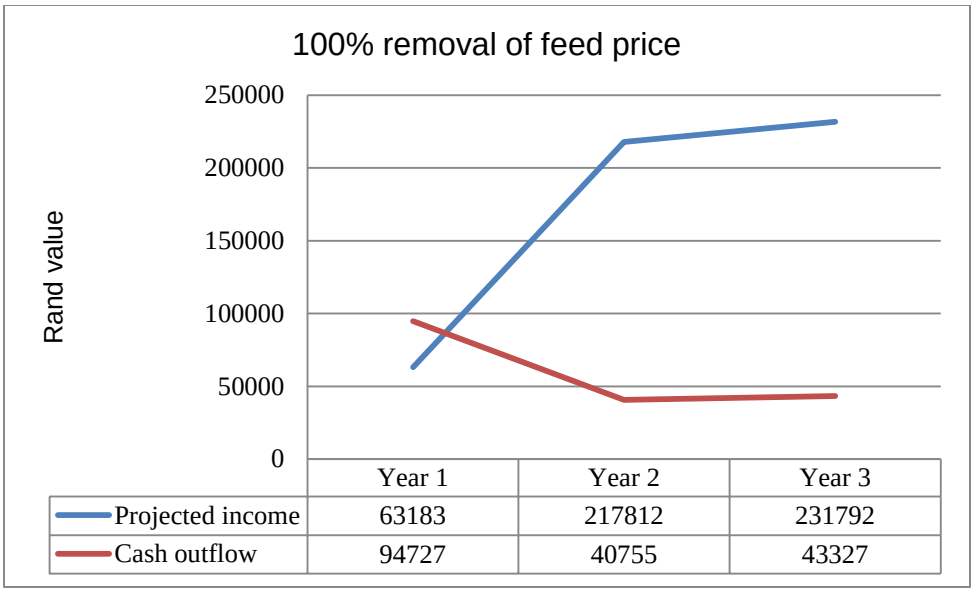


Figure 4.13c: One hundred percent (100%) removal of commercial feed price

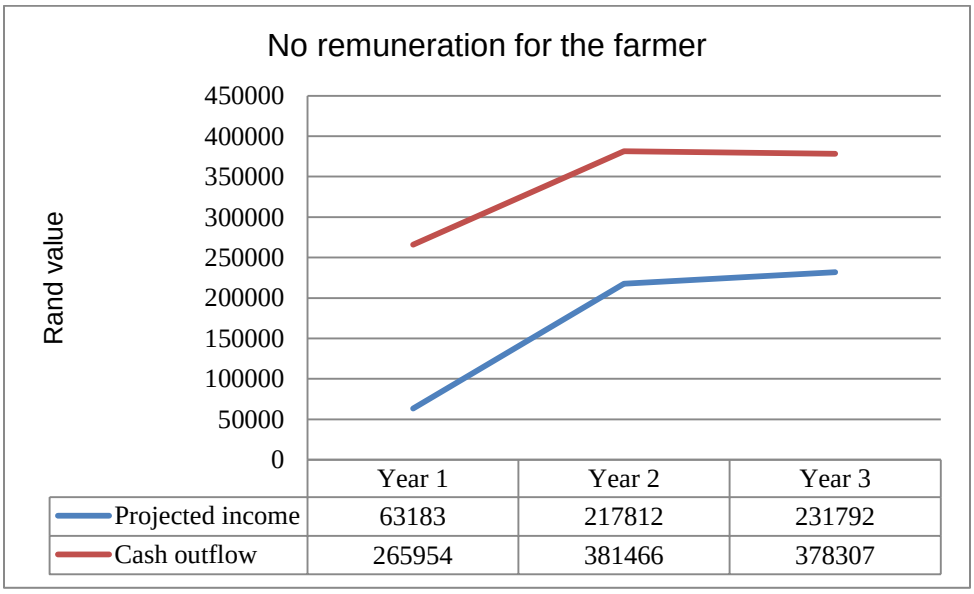


Figure 4.13d: No remuneration for farmer

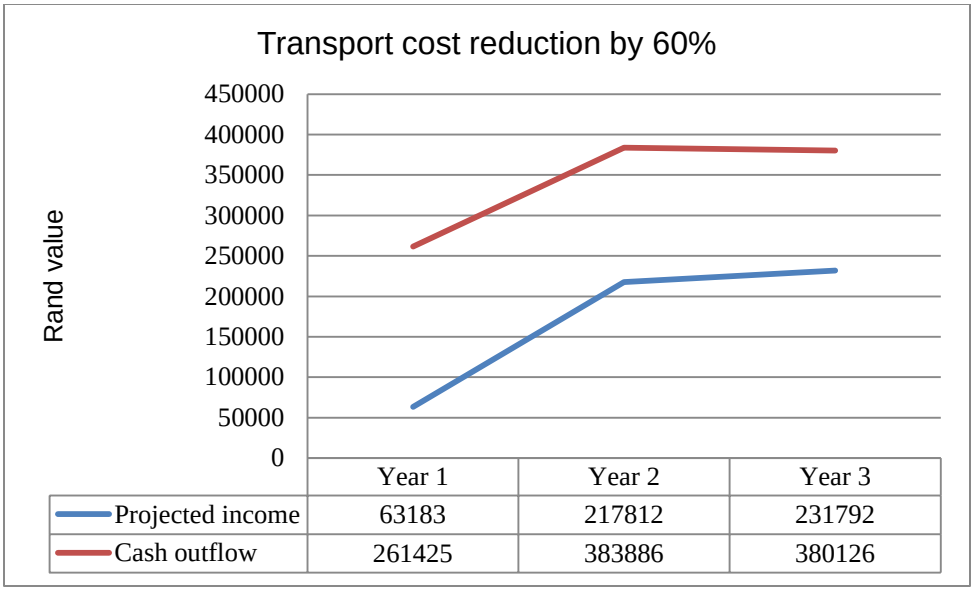


Figure 4.13e: Transport cost reduction by 60%

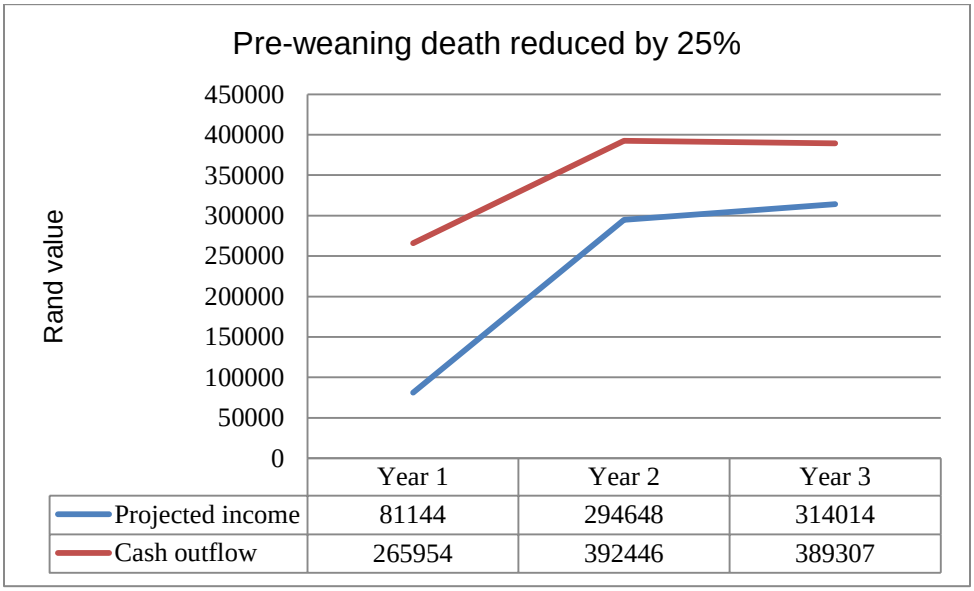


Figure 4.13f: Pre-weaning death reduced by 25%.

CHAPTER 5.0 DISCUSSION AND CONCLUSIONS

5.1. Farmers socio-economic characteristics

This work has explored the issues associated with pig production among smallholder farmers in Mpumalanga considering the climatic conditions and production parameters. The farmers' population structures of smallholder pig farmers in Mpumalanga has been described and it resembled what has been reported elsewhere in South Africa (Mokoele *et al.,* 2014) and other parts of Africa (Nsoso *et al.,* 2006; Nath *et al.,* 2013). Since pig production is labour-intensive, and the ownership of land is a critical factor to successful pig production, these factors may affect the level of women participation in this activity. Women in parts of Southern Africa have been identified as primarily landless and are often denied the opportunity to participate in animal agriculture when compared with men (Cross and Hornby 2002; Kalabamu, 2006). Culturally, men are believed to be the owners of the livestock in the family and the reason majorities of pig farmers were men could be influenced by the landlessness of women. Mokoele *et al.* (2014) have explained these limitations in the context of pig production in Limpopo, South Africa.

5.2. Comparison of socio-economic characteristics in different agro-ecological zones of Mpumalanga

Mpumalanga pig farming is predominated by males 63.6% but the lowveld had 56.8% of female respondents who participated in pig rearing; this is not surprisingly because similar results were reported in Eastern Cape in South Africa (Madzimure e*t al.,* 2012) and elsewhere (Njuki *et al.,* 2010; Chittang *et al.,* 2012; Halimani *et al.,* 2012). Because the level of educational was generally low and the majority of respondents were poor to just below average in economic status, these might have influenced some women participation in pig rearing in the lowveld region to boost family income. Mashatise *et al.* (2005) and Halimani *et al.* (2012) have previously indicated in their study that women who participated in pig production were from low-income group, who may want to improve the economic statuses of the families.

5.2.1 **Relative advantages in the three agro-ecological zones in terms of production and profitability of Mpumalanga province**

Based on the results obtained from this study, the three agro-ecological zones have transformed from the purely traditional rearing of indigenous breeds, particularly the Lowveld (94.6%) and the Midveld (91.1%). This represents a positive sign since exotic breeds and their crosses have better growth potentials than the indigenous breeds. The use of exotic breeds and their crosses is advantageous for market access as auctions and abattoirs prefer those two compared with the indigenous breeds. Furthermore, exotic breeds farrow relatively larger litters compared with the indigenous breeds. In this case, more pigs will be reared, sold and more profit will be generated. In this study, though the majority of smallholder pig farmers reported the rearing of exotic breeds in the three agro-ecological zones, smaller-sized litters (six to 10 piglets/farrowed/sow/litter) were recorded possibly due to a combination of other management factors.

Furthermore, the uses of the boars acquired from unreliable sources were seen as a major constraint. The results of this study indicated that many breeding boars were borrowed from neighbour and relatives (59.1%), or sourced from the auctions and other sources (**Table 4.2)**. The system is risky and potentially dangerous in pig production as untested and culled boars are sold in auction and may have implications for disease introduction to farms. In other cases, breeding boars were obtained from pig breeders and farming projects and these are certified to be of good quality compared to breeding boars from auction and neighbours. A correlation can be inferred between the lowveld where boars sourced from project were higher compared with others and the number of piglets farrowed per sow per annum (>16). In addition, a good boar will assist the sows to achieve record farrowing of 2-3 litters per annum or five conceptions and farrowing in a space of two years. It is advisable for the smallholder pig farmers to procure the breeding stock from reliable source such as pig breeders and pig projects to improve the piglets/farrowed/sow/litters and control diseases. Anecdotal evidence had indicated that most of the animals marketed in the auctions are culled, unthrifty, unproductive, animals with defects, or old animals with bad records of sickness.

Animal nutrition is cardinal in the pig production and good nutrition cannot be overemphasized. Unfortunately, smallholder pig farmers in Mpumalanga predominantly feed swill in all the three agro-ecological zones. The perception that swill reduces the cost of input and enhances output-

input balance was never weighed against the animal health, welfare and productivity. In this study, the majority (91.3%) were observed to be in very poor to fairly good body conditions. The very poor body condition to poor body condition is not unconnected to the poor feeding regime (quantity and quality) provided for the pigs daily (**Table 4.5**). The above situation is also linked with high mortality during pre-weaning stage (**Fig. 4.1a**) and reduce the value of the pigs significantly when presented at the auctions and abattoir; as such the smallholders are forced to sell locally via slaughtering or pig sale to neighbours (**Figure 4.9**) using prevailing local price (**Figure 4.10**).

In terms of housing, the highveld and midveld zones mostly practice semi-intensive production while the lowveld are predominated by semi-intensive extensive management system (**Table 4.2**), with implications for management practices like gestation, farrowing and during the lactation period. These two former zones also confirm acceptable level of pre-weaning mortality (0 -10%) (**Figure 4.1a**). This study confirmed that good housing minimizes the mortality experienced in smallholder pig farming.

In terms of market, lowveld zone had the highest percentage of the farmers who slaughter/ sold live pigs locally and few sold the pigs in one of the biggest abattoirs in the zone. Lowveld is situated on the redline zone and pig farmers are prohibited from selling their pigs in another district as a form of diseases control. The kind of system used at lowveld is an advantage to farmers because there are no transport costs and no pig condemnation. Highveld and midveld accommodate major auctions areas in the province, many of the respondents in these two areas also indicated preference to market their pigs at auctions. These recent results indicated that there is a realistic chance for the farmer in highveld and midveld to emerge as they have easy access to the market.

Furthermore, the midveld (37.5%) had the majority number of respondents who received financial assistance from the government and the least number of respondents who received any kind of training in pig production and management. It is advised that for any farmers to receive support from the government, it should be backed up by training to optimize the assistance

received. This kind of method will assist to minimize some minor problems observed in this study, improve the pig management and enhance profit in smallholder pig farming.

5.3. Interested age group in smallholder pig farming of Mpumalanga

A total of 78.7% of the smallholder pig farmers in Mpumalanga province were >51 years of age, many of whom were pensioners, an indication that the average age of pig farmers was advanced. In some areas, respondents indicated the reason for raising pigs as: entertainment to keep them busy, for sale and or household consumption. The youth respondents were very few and some young people who owned pigs indicated to have received the pigs from their parents or inherited them. This result indicates the decline of pig farming in future as youth are not interested in pig farming. There will be a need to institute drives that encourage young individuals to participate in animal agriculture.

5.4. Reasons for pig farmers poor performance

The proportion of individuals who received agricultural training was low (20%). Insufficiency of specialized agricultural extension officers in the provision of pig husbandry training has been reported as a limitation in Botswana (Moreki and Mphinyane, 2011). The low percentage of trained pig farmers in Mpumalanga can partially explain the reason why poor management knowledge was one of the leading causes of piglets' deaths. It will appear that larger family tend to go into pig husbandry; whether this is due to availability of labour in the families or the need to supplement family income was not evaluated in this report.

5.5. Housing systems

Approximately 25% of the respondents practiced free range in Mpumalanga province, and 42% of all respondents from the lowveld practiced free ranging management system. This management style is often practiced during the winter when there is scarcity of crops in the fields. It is observed that during the data collection, some peri-urban pigs were seen scavenging around the township for feeds sewerages and garbage areas. The implications of this situation for

animal diseases and zoonotic infections are obvious. In addition, farmers allow pigs to free range for breeding boars and feeds to keep the inputs low (Lekule and Kyvsgaard, 2003; Mutua *et al.*, 2010). In some areas, certain community members who did not rear pigs expressed concerns on scavenging pigs around the human dwelling areas citing the fact that pigs destroy their crops and the odour from the sty was intolerable.

The highveld has the least number of respondents that practiced free range (21.4%), and the majority of respondents reside in peri-urban areas. It will appear that the location of pig farm influence the farming system used by the farmer (**Table 4.1**). Phengsavanh *et al.* (2011) had earlier reported the same as in the lowveld (43.2%) in Mpumalanga where scavenging pigs rearing were mostly seen in the remote areas. According to our results, about 91% of the respondents in lowveld were from rural areas compared to figures from the highveld (46.5%) (**Table 4.1)**. Highveld and midveld of Mpumalanga are characterized by cold winters (**Figure 3.3**); this might be the other reason why pig production in these two zones was mostly intensive and or semi-intensive.

In terms of housing, the majority of the pig pens observed during data collection were built out of locally available materials. This housing type has been observed previously (Nath *et al.*, 2013). In addition, old houses not purpose-built for pig housing, sty built out of old corrugated iron, fence, plastics and woods were also seen. Most of the pens observed did not meet the required standard for pig rearing (**Figure 4.2**). It is desirable that a good pig pen should protect the piglets from ambient temperature to ensure survival (Dietze, 2011), and to protect them from predators and diseases (Kyriazakis & Whittemore, 2006). Because pig farming attracts the most disadvantaged members of the community in Mpumalanga province, cheap local materials were primarily used to design pig pens and reduce the cost of housing the livestock. In our evaluation, the majority of the respondents (78.2%) were just below average to poor and about 72% had ≤grade 11. Whereas the hypothesis was not tested, it is highly likely that there will be association between these poor housing and late marketing of pigs at >7 months of age (61.8%) and sows in very poor to barely good (2.5 – 3) body condition scores (91.3%) because no creep area (which provide warmth to piglets) were observed. It is expected that the piglets will use most of the energy to generate heat for their bodies instead of using energy for growth (Roelofse, 2013). In

addition, good housing will protect pigs from diseases, stress which causes slow growth and unnecessary mortalities which were observed in this study.

5.6. Pig breeds preference amongst smallholder pig farmers of Mpumalanga

Because the majority of respondents (89%) kept exotic and cross-bred pigs, the prospect of improving pig agriculture and boosting agricultural potentials are tremendous among these smallholder farmers. Njuki, *et al.* (2010) had reported that the keeping of exotic and cross-bred enhance better growth rate, feed conversion efficiency and promote larger litter size (Rahman *et al.*, 2008). In Kenya, low genetic potential, malnourishment, high parasite prevalence and disease have been identified as reasons for low average daily gains (ADG) in smallholder pigs (Carter *et al.*, 2013). In this study, these identified factors did not play a significant role in poor returns in pig farming at smallholder levels. While these are the positive development, they must, however, be supported with good management and bio-security practices, training, vaccination and appropriate healthcare.

In view of the multiplication of exotic breeds of pigs, there has been a relative decline of local breeds. A similar result has been reported from India (Nath *et al.,* 2013). In Mpumalanga province, the animal management practices were poor, and only 17% implemented vaccination, over 90% did not keep any record and ≈ 96% did not weigh before sale. These identified areas will need significant improvement and more interactions from the agricultural and veterinary authorities within the province will enhance service delivery in these areas.

5.7. Pre-weaning constraints

In this study, half of the farmers reported that pre-weaning mortality was within the acceptable range (≤ 10%). Elsewhere, pre-weaning mortality approached 18% in Australia (McCosker, 2014), 18 to 24% in Central Lao PDR (Chittavong *et al.,* 2012), 9.5 to 21% in Congo (Kambashi *et al.,* 2014) and 22.6% in the USA (Li *et al.,* 2010). The careful breeding programme, selection of boars with good litter scatter, efficient management and optimum feeding of sows in pregnancy, pre-lactation and during lactation, correct vaccinations and assistance during farrowing as well as careful management of piglets and weaners will significantly cut these

unnecessary losses. While the post-weaning mortality was largely within the limit, about 10% was associated mainly with diseases in weaned pigs. Appropriate measures mentioned for pre-weaning mortality above will correct or reduce these incidences similarly (McCosker, 2014).

5.8. The causes of mortalities during pre-weaning

The lead causes of mortality in this study were weak born piglets/crushing, neonatal diseases, lack of management knowledge and malnutrition. Other studies have confirmed similar causes of avoidable neonatal deaths (NAHMS, 2000; Mokoele et al., 2014). Although the listed causes are discrete, interactions of factors are responsible for majority of the cause of death in piglets and weanling pigs. However since weak piglets were crushed in over 50% of the cases and about 4.3% of the dead piglets were due to cannibalism as a result of accident in the farrowing house, it is suggested that improved housing condition should be implemented to reduce incidences of pre-weaning mortality in piglets in smallholder farms.

5.9. Feeds types in three agro-ecological zones of Mpumalanga

In the surveyed areas in the lowveld, more than half of the farmers depended on leftovers to feed the pigs (**Figure 4.7**), in this area, tropical fruits and vegetables are available throughout the year compared to the other agro-ecological zones, whilst maize was mostly fed in the highveld. Nevertheless, feeding of leftover has been reported to contain certain imbalances, poor nutritional values and to a high amount of carbohydrates and possibly salt (Kagira *et al.*, 2010; Mutua *et al.*, 2012). While pig farmers ignore the fact that feeding swill does not have all necessary energy, protein, minerals and vitamins required in pig feeds, they continue to use these resources without respite to correcting the imbalances (Roelofse, 2013). Pigs were fed on kitchen swill (Kumar *et al.*, 2010) and other materials to reduce the feeding cost (**Figure 4.8**). Whereas it has been suggested that pigs that are fed with leftovers should be vaccinated against *botulism*, in this study approximately 83% respondents in Mpumalanga did not implement vaccination of any kind. Not implementing vaccination remains a risky behaviour that may increase the chances of disease spread (Schembri *et al.*, 2013).

In this work, the feeding of uncooked vegetables from the gardens and restaurants was reported by many, it is believed that these materials have potentials to cause certain diseases in pigs. In the

Sikkim Himalayan region in India, vegetables were cooked before feeding to pigs (Nath *et al.*, 2013). Official documents have recommended that all forms of swill should be cooked before feeding and it will benefit the national animal health to implement this at smallholder enterprises. Similarly, a good proportion (43.46%) of the respondents in the highveld fed leftovers and a significant number of respondents (49.6%) were reported to be from peri-urban areas, it should be understood that farmers in peri-urban areas have access to leftovers from the restaurants, schools, hospitals, vegetable markets and the feeding of leftovers will appear to be a matter of convenience and costs (Phengsavanh *et al.*, 2011).

The higher price of feeds was a major factor for taking important farm-related decisions for the below the average to poor individuals (**Table 4.1**). Adequate training on the pig management including the importance of vaccination and diseases management such as *Salmonella, Campylobacteria, Foot and Mouth* and *Classical swine fever* can highlight the relationship between swill and animal diseases to these farmers (Turton, 2002).

5.10. Breeding boar source in smallholder pig farms of Mpumalanga

In addition, in Mpumalanga province, more than three-quarters of the respondents participate in risky behaviours like borrowing breeding boars from the neighbour, relatives, auction, and from free range sources. Similar results were reported in Northern Lao PDR and elsewhere (Phengsavanh *et al.*, 2010, Halimani *et al.*, 2012, Halimani *et al.*, 2013). Selection from own boar may result in inbreeding and weakening of the genetic pools. Certain unwanted recessive genetics may also result (Halimani *et al.*, 2012). Perhaps, the low numbers of piglets per sow per year and poor body condition observed in this study were associated with this hypothesis. It becomes necessary to test such hypothesis and implement the programme that will continually enhance improved genetic potentials among these farms. Only 16.8%of the respondents buy from the local breeding projects and pig breeder in this study.

5.11. Associations of agricultural assistance with agricultural training

The association study showed that the receipt of agricultural assistance from government and agricultural training positively influence some of the farm inputs and outputs, the government

should explore how these identified inputs can be distributed to reach committed farmers within the province and perhaps nationally, and service providers should be engaged to facilitate agricultural training for smallholder pig farmers. Mokoele *et al*. (2014) have earlier advocated for the implementation of same in Limpopo province.

Whereas the variables tested differed slightly between the three agro-ecological zones, clear differences existed in some variables. For example, women form a significant proportion of the lowveld region, the rural population was significantly higher in the lowveld, the highveld had a significant higher peri-urban population compared to the others, poor to no weaning was high in midveld compared to others and the lowveld's pre-weaning mortality, feeding of leftovers and local slaughter/number of pigs sold alive was higher than in the other agro-ecological zones (**Table 4.1 and Figure 4.1a**). It is highly likely that the warmer moist condition of this region as well as a comparative low level of education impact on neonatal pathogens' (like *Escherichia coli* and *Isosporasuis*) multiplications and growth and aggravated the situations of piglet mortalities in this region.

5.12. Production and profit determinants

In Mpumalanga, there are at least fifteen identified auctions which are randomly dispersed. Many of the smallholder farmers market their pigs at auctions or within the communities. Because strong correlation exists between auctions and prevailing market price, it can be inferred that high pig populations at auctions are indications that the prevailing market prices are good. As such, market price is a driver for moving pigs to auctions. Such pigs often miss pre- and post-mortem inspections and may inadvertently spread infectious disease. It becomes necessary to identify each auction within Mpumalanga and know the farms and road networks that support them so as to plan and apply intervention strategies where and when necessary, for example in the case of rapidly spreading animal disease, or for surveillance purposes. Secondly, market price has some degree of influence in moving pigs to the abattoirs but only a minority (8.3%) preferred this option for marketing. Similar results have been reported from Limpopo province where farmers travelled a long distance to obtain higher prices primarily at auctions and at abattoirs (Mokoele *et al.*, 2014).

Furthermore, because of the correlation that exists between local price and local markets (0.7261), it can be inferred that the local market is highly influenced by prevailing local price, with minor influence from the age of the pig and gender. Primarily, sick, unthrifty pigs, mature boars and late maturing pigs are slaughtered locally. Comparatively, prevailing market prices are higher than the local price range and better quality products are often sent to the auctions (51%) and commercial abattoirs (8.3%). It is known that pork from mature boars has pheromonal smell (*androstenone and skatole*), and generally attract much lower price compared with other pigs. In addition, slow growing late maturing pigs are characteristics of most smallholder pig producers, an indication that they will be presented for slaughter at later age. It is therefore not surprising that local market and age of pigs somehow correlated.

Although minor positive correlation exists between auctions and self-medication, our qualitative evaluation has revealed that smallholder pig farmers who sell at auction and elsewhere tend to self-medicate with prevalent use and abuse of long acting oxytetracycline and ivermectin. Similar abuse has been established in Limpopo province (Mokoele *et al.,* 2014) and elsewhere (Fasina *et al.*, 2012). Although DARDLEA has public veterinarians and animal health technicians in all the districts and municipalities within the province who provide free services to smallholder farmers, it will appear that smallholder pig farmers lacked information about veterinary services in the province. Primarily, these farmers hardly consult veterinarians and para-veterinary professionals (**Table 4.1**). Reasons for this disconnect must be established and a drive to gain smallholder farmers' trusts and to make service accessible and affordable must be implemented.

Local slaughter for household consumption and within the community sale was prevalent in a recent study group (64%) and this carries a high risk of animal and public health since pre-slaughter pig inspections are neglected as highlighted above. Whereas local slaughtering for community sale is prohibited by law, slaughter for household consumptions is allowed (Anonymous, 2000 [Meat safety Act no. 40 of 2000]).

There is a certain degree of correlation between auction and gender of animals and the reason for this observation is not far-fetched: top quality breeding boars are out-priced beyond the reach of smallholder farms and good commercial boars are equally pricey. As such, the smallholder farms have to settle for lower quality boars sourced from auction markets. This practice further exposes

the smallholder farms to risks of infectious animal diseases and the genetic values of the boars are doubtful. It will become important for agricultural authorities to revise their strategies, evaluate these gaps and devise means of addressing it. A good stopgap measure may include the creation of the district and municipal pig breeding centres from where quality genetics may be multiplied and distributed to smallholder farmers at minimum costs. Such intervention carries additional benefits of training in animal production, animal health, bio-security and employment generation.

Grossly, the feeding of swill correlated with poor body condition, which in turn correlated with less number of the piglets born/sow/litter (1- 5 piglets) and this less number of the piglets born/sow/litter (1 -5 piglets) correlate with feeding of swill, it was inferred that the feeding of the swill alone will lead to poor level of reproduction (less number of piglets per litter) and poor body growth (**Tables 4.8 to 4.9**). Conversely, the pigs that are fed with commercial feeds or commercial feeds mixed with swill tend to be in better body condition and produce more piglets/ sow/litter (11- 20 piglets). The lowveld had the majority reported to feed leftovers (**Figure 4.7 to 4.8**) and body condition (**Figure 4.4 to 4.5**) were observed to be very poor to poor (45.9%), additionally because the pigs were in poor body condition, the majority preferred to sell the pig locally using local price. Adding to the above statement 95.87% in the Mpumalanga indicated not to weigh the pigs before selling, these seemed as a way to be avoiding the decline from the customers as pigs were very poor to poor (**Figure 4.5).**

5.13. Market challenges

Furthermore, a majority of participants' claimed to use profit (66%) received from pig rearing for pig maintenance but it appears that many (47%) fed leftovers to the pigs and when it comes to health, sick pigs were left to die, to recover or slaughtered (35.6), some treated sick pigs with ethno vet preparations (13.2%) and just 17.4% consulted professionals which include government animal health technicians and veterinarians and some who consulted private veterinarians (**Table 4.5**). The government professionals in DARDLEA offers free consultations to the smallholders around the province. In this observations, smallholders occur to be using the profit for own self-development and household needs instead of expanding the business.

In terms of home slaughter, approximately 35.6% respondents in Mpumalanga indicated to slaughter sick pigs to avoid medical costs and lose of livestock (**Table 4.5**). The home slaughter observed in this study was practiced outdoors under the tree. Water for shaving the hair was boiled using big pots, the tree was used for hanging the pig during shaving of the hair and the table was used for cutting the pig (**Figure 5.11**). This kind of system is connected to disease transfer among animals and human as birds can spread the diseases. Therefore, intervention from the Department of Agriculture, Rural Development, Land and Environmental Science, the veterinary services is needed in this matter as the health of human and animals are in great danger.

5.14. Economic model of smallholder farms

Using partial budgeting and return-on-investment (ROI), the 10-sow unit pig farm is economically unsustainable with commercial feed. It will appear that the main driver of profitability in smallholder pig farms is the feed cost. Whereas the profitability of a pig production unit increases as the number of live born piglets per litter increases (Kyriazakis & Whittemore, 2006), our work only partially agreed with this assertion. Even though the production efficiency increased and pre-weaning mortality was reduced by 25%, a 10-sow pig production unit was still not able to break even in this analysis.

Feed is an undisputable pig farm input of utmost importance and our analyses have confirmed the same (Kyriazakis & Whittemore, 2006). It was the most important determinant of profitability in smallholder farms. Although it will appear that the utilization of commercially compounded ration by farmers will yield better quality products and improve reproduction and overall production, at this scale of production, it was not financially feasible and viable. Roelfse (2013) has previously highlighted some of the reasons for the relative high feed cost and suggested reasons why smallholder pig farmers rely on swill as an alternative form of feed (Phengsavanh *et al.,* 2010). It is similarly concluded that due to the infeasibility of feeding commercial ration, smallholder farmers will continue to feed swill and alternative feed sources for the unforeseeable future.

It is potentially possible for smallholder pig farmers to make the profit (Lapar & Staal, 2010; Petrus *et al.*, 2011; Phengsavanh *et al.*, 2011) and that was demonstrated in this economic analysis. However, the ≤ 10-sow unit smallholder farmers in Mpumalanga were able to achieve profitability mainly through the use of swill as a major source of feed. This practice is common to most smallholder pig farms elsewhere in South Africa (Gcumisa, 2013; Roelofse, 2013). The feeding of swill comes with potential risk of spread of diseases to pigs [e. g. Salmonella, Campylobacter, African swine fever (ASF), Classical Swine Fever (CSF), porcine reproductive and respiratory syndrome (PRRS) and Foot-and-mouth disease (FMD)] and possibly from pigs to humans (Haynes, 2001; DAFF, 2005; Beltrán-Alcrudo *et al.*, 2008). In addition, pig products originating from swill feeding are not acceptable in the South African pig abattoirs.

In view of the above risks and knowing that it is more realistic to make the profit with between 50 and 100-sow unit for smallholder farmers (Roelofse, 2013), it is suggested that the agricultural authorities should assist farmers in the development of community self-help groups and farmers' cooperatives. Such calls have been made previously (Munyai, 2012) and the successes associated with such organization by smallholder pig farmers have been documented in Namibia (Petrus *et al.*, 2011), Vietnam (Lapar & Staal, 2010) and Lao People's Democratic Republic (Phengsavanh, *et al.*, 2011). Such cooperative organization will have the advantages of bulk purchase of feed with benefits of economies of scale and discounts (Costales *et al.*, 2007; Lapar & Staal, 2010), reduced transport tariffs through bulk transport, and better-negotiating power.

In addition, because an improvement in efficiencies and reduction of pre-weaning loss by 25% will improve profitability, it becomes necessary to implement the steps to achieve these objectives. The government may also consider tax rebates on animal feed products that are directed to smallholder pig farmers. Only through the combination of the above measures and interventions will smallholder farmers with ≤ 10-sow unit be able to break even and utilize pig production as poverty alleviation means.

Mpumalanga smallholder farmers in will benefit from carefully designed or restructured agricultural programmes that focus on training-linked agricultural inputs, more women and youth

participation, supply of improved breeds and oversight functions. Youth should be motivated to venture into pig farming as third quarter of the respondents were >40 years. In this study, differences in agro-ecological zones primarily were not associated with differences in farm outputs among smallholder farmers.

Smallholder pig production and health management will continue to be relevant in an emerging economy like South Africa. However, for government agricultural interventions to come with desired benefits, empirical evaluations for technical and economic feasibilities must be carried out. Although a 10-sow unit is technically feasible, in Mpumalanga and elsewhere in South Africa, the current input systems negates the benefits that should come with such programmes. Proposed models and revisions as suggested above may facilitate government interventions and make it more attractive to smallholder farmers.

The pig breeding is one of the vital factors in pig production, smallholders indicated not to be having breeding boars; the department must execute projects that will breed the breeding boars for smallholder farmers, as boars in commercial are expensive and unreachable. The above can be reached by using the state research farms available in the province.

The performance of the pigs in Mpumalanga can be improved through proper feeding, instead of feeding leftovers and kitchen swills which was the most practiced in this study. The department of agriculture should provide subsidy of feeds to smallholder pig farmers. Co-operatives should be established to allow farmers to buy feeds and medications in bulk. This will enable them to take advantage of the bulk discount.

About 35.6% respondents reported to slaughter the sick pigs to avoid the medication costs. This method of practice is dangerous to public health; therefore, the Department of Agriculture intervention is highly needed.

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THE APPENDIX 1

TOPIC: EVALUATION OF PRODUCTION SYSTEMS AND CONSTRAINTS IN SMALLHOLDER PIG FARMING IN THREE AGRO-ECOLOGICAL ZONES OF MPUMALANGA PROVINCE, SOUTH AFRICA.

Dear Sir / Madam

The survey is conducted in Mpumalanga Province, in three different agro-ecological zones to determine the status of the small holders pig farming in Mpumalanga province.

Please do not enter your name on the questionnaire. It remains anonymous. Information provided by you remains confidential and will be reported in summary format only. Your participation in this research is confidential and in the event of a publication or presentation resulting from the research, no personally identifiable information will be shared. Your decision to be part of this research is voluntary and you may stop at any time you wish. You do not have to answer any questions if you do not want to.

Should you have any queries or comments regarding this survey, you are welcome to contact me e-mail us at priscilla.munzhelele@gmail.com

Kindly complete questionnaire and return it to Private Bag X 9019, Ermelo, 2350

Yours sincerely

Priscilla Munzhelele (Msc. Student at University of South Africa)

Questionnaire number	

Ecological zone	

Co-ordinates	

PLEASE ANSWER THE FOLLOWING QUESTIONS BY CROSSING (X) TO THE RELEVENT BLOCK OR WRITING DOWN YOUR ANSWER IN THE SPACE PROVIDED.

A. SECTION A

Example of how to complete this questionnaire

Your gender? (If you are **male**)

Male	1 X
Female	2

Or

(If you are **female**)

Male	1
Female	2 X

1. Gender

1	Male
2	Female

2. Age

1	<20
2	21 – 30
3	31 – 40
4	41 – 50
5	>51

3. Ethnicity

1	Black
2	White
3	Coloured
4	Indian / Asian

4. How would you describe your economic status?

1	Poor
2	Below Average
3	Average
4	Above Average
5	Affluent

5. Your highest educational qualification?

1	No schooling
2	Grade 11 or lower
3	Grade 12
4	Post-matric Diploma or above

6. How would you describe the area in which you are residing?

1	Urban
2	Rural
3	Peri-Urban

7. Size of your household, i.e. the number of people, including yourself, who live in your house/dwelling for at least three months of the year?

1	1 (Live alone)
2	2
3	3 - 4
4	6 – 8
5	More Than 9

SECTION B

This section is about the management practices, types of feeds and feeding practices, housing types, preventative measures, breeding and production records

8. What type of breed are you using?

1	Large white
2	Landrace
3	Large white x Landrace
4	Large Black
5	Pietrain
6	Duroc
7	Gloucestershire
8	Kolkoek
9 Other (Specify):	

9. How many sows do you have? | |

10. How many boars do you have? | |

11. Where do you get your breeding boars?

1	Pig breeders
2	Neighbor
3	Relatives
4	Select from your boars
5	Auction
6	Other (Specify):

12. Does the boar stay with the sow?

1	Yes
2	No

13. Do you take boar to the sow?

1	Yes
2	No

14. How long does the boar stay with the sow? Hours: _____ days: _____ Months: _____

15. How many piglets does one sow usually farrow? | |

16. Why are rearing pigs?

1	Tradition
2	Household consumption
3	Sale
4	2 and 3
5	All of the above
6	Others (Specify):

17. What housing system do you use?

Intensive ☐ Semi-intensive ☐ Free ranging ☐

18. What do you feed on your pigs? (You can tick more than one)

1	Buy feeds
2	Vegetables swills
3	Restaurant / school swills
4	Hospital swills
5	Home Leftovers (food)
6	Free range
7	All of the above
8	Others (Specify):

19. How many times per day do you feed? ☐

20. The mortality rate during lactation

21. The mortality rate at weaning

22. What causes mortality?

1	malnutrition
2	diseases
3	Weak newborn piglets
4	Predators
5	Lack of knowledge
6	Others (Specify):

23. Diseases usually encountered?

_____

24. Do you vaccinate your pigs against certain diseases?

1	Yes
2	No

25. Mention the type of vaccine you use: _____

26. Do you keep records of your pigs?

1	Yes
2	No

27. What kind of records? _____

28. Body condition of the pigs

1	Extremely poor
2	Poor
3	Good
4	Very good
5	Overfat

29. At what age do you wean? [ ]

30. How many times does the sow farrow in a year?

1	Once
2	Twice
3	Thrice

31. Do you weigh your pigs before selling?

1	Yes
2	No

32. Where do you market your pigs?

1	local
2	Abattoir
3	Auction

33. How do you determine the price?

1	Local price
2	Market price
3	Age of the pig
4	Gender
5	Others (Specify):

34. How do you use the profit?

1	Education
2	Maintenance of pigs
3	Home groceries
4	Specify:

35. How often do you sell your pigs in a year? ☐

36. At what age do you sell your pigs?

1	6 months or less
2	7 months to 18 months
3	19 months above

37. How do you treat a sick pig?

_____

38. Have you ever been trained on pig husbandry techniques, feeding, vaccination and breeding?

1	Yes
2	No

39. Do you get assistance from agricultural advisors and veterinary service?

1	Yes
2	No

Thank you for your co-operation in completing this questionnaire. Kindly return the questionnaire as specified in page one.