

**RISK FACTORS AND ECONOMIC IMPLICATIONS OF AFRICAN SWINE  
FEVER IN THE PIG VALUE CHAIN IN SONGWE AND RUVUMA REGIONS,  
TANZANIA**

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**A THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR  
THE DEGREE OF MASTER OF PHILOSOPHY OF SOKOINE UNIVERSITY OF  
AGRICULTURE. MOROGORO, TANZANIA.**

## EXTENDED ABSTRACT

African Swine Fever (ASF) is a highly contagious hemorrhagic disease of domestic and wild pigs. The disease has economic consequences not only to food security and people's livelihoods but also on international trade as its occurrence and prevalence may result in trade restrictions. Given direct and indirect losses attributable to the disease, an understanding of risk factors associated with its outbreaks and economic implications of the disease on pig value chain actors is of paramount importance. This study was conducted with the aim to providing information in these respects. The study employed value chain approach to determine risks factors and the economic implications of ASF in Songwe and Ruvuma regions of Tanzania. Primary data were collected using structured questionnaires, and semi structured key informant's guide. Observation was used to assess structure, facilities and practice within chains. Data were analyzed using Statistical Package for Social Sciences (SPSS) whereby descriptive statistics were computed and logistic regression analysis performed. Spreadsheet model and Gross Margin were used to determine financial losses associated with ASF. The findings show that main actors were pig producers, assemblers, wholesalers, rural and urban retailers. Unknown stock source (30%), poor husbandry such as free ranging (5%), poor management of waste products (73%) and poor handling of feed (73%) were risk practices in the production node. Transportation nodes operated under high risk due to frequent movements and pick-ups of  $\geq 30$  pigs per trip. Risk factors associated with ASF outbreak in Songwe region were sharing of boars ( $P < 0.01$ , OR= 7.05 and CI<sub>95%</sub>=1.78; 28.00) and sharing of farm equipment ( $P < 0.04$ , OR= 4.14 and CI<sub>95%</sub>=1.07; 16.09). Presence of bush pigs ( $P < 0.01$ , OR= 3.08 and CI<sub>95%</sub>=1.33; 7.14) and visitors access to farm ( $P < 0.01$ , OR= 2.38 and CI<sub>95%</sub>=1.23; 4.61) were positively correlated with ASF outbreak in Ruvuma region. During ASF outbreaks, high mortality occurred in piglets (31%) and in adult sows estimated at

29%. The estimated direct losses on pig producers were about 119 615 883 TZS in Ruvuma and 165 785 000 TZS in Songwe. Indirect losses on traders due to trade restrictions were estimated at 5 665 000 TZS in Songwe and 18 799 350 TZS in Ruvuma. Therefore, there is a need to improve good husbandry, marketing infrastructures and formation of pig business associations to improve pig value chain structure and organization. There is also a need for strengthening veterinary services on routine disease surveillance and training on disease risk manifestation for early detection, reporting and disease control. The research findings reported in this study provide an insight on sources and economic implications of the disease in affected areas which is very useful in prevention to other areas in Tanzania which are potential for ASF outbreaks.

## DECLARATION

I, Ntuli Ngosomwile, do hereby declare to the Senate of Sokoine University of Agriculture that this thesis is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.



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## **DEDICATION**

This work is dedicated to my beloved son Bryan Benard for his patience throughout my study, to my Late Mother Atuganile R. Mwajeka, and to my Late Young sister Gwantwa Ngosomwile who passed away before I completed my degree.

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**LIST OF ABBREVIATIONS AND SYMBOLS**

ASF	African Swine Fever
ASFV	African Swine Fever Virus
AU	African Union
CI	Confidence Interval
CCPP	Contagious Caprine Pleuropneumonia
CSF	Classical Swine Fever
DFA	Direct Fluorescent Antibody
DNA	Deoxyribonucleic Acid
DRC	Democratic Republic of Congo
EA-ASF-WG	Eastern African Swine Fever Working Group
ELISA	Enzyme- Linked Immunosorbent Assays
<i>et al</i>	and others
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	FAO Statistical Database (United Nations)
FLM	Field Livestock Officer
FMD	Foot and Mouth Disease
GDP	Gross Domestic Products
GM	Gross Margin
HPAI	Highly Pathogenic Avian Influenza
ICT	Information and Communication Technology
IFA	Immunofluorescence Assays
ILRI	International Livestock Research Institute
Kg	Kilogram
ODK	Open Data Kit

OIE	World Organisation for Animal Health
PCR	Polymerase Chain Reaction
pH	Hydrogen ion Concentration
PPR	Peste des petits Ruminants
PRRS	Porcine Reproductive and Respiratory Syndrome
RVF	Rift Valley Fever
SACIDS	Southern African Centre for Infectious Diseases Surveillance
SPSS	Statistical Package for Social Sciences
SSA	Sub Saharan Africa
TR	Total Revenue
TVC	Total Variable Cost
TZS	Tanzania Shillings
URT	United Republic of Tanzania
USA	United States of America
USDA	United States Department of Agriculture
VIF	Variation Inflation factor
°C	Celsius or Degree centigrade
%	Percentage
<	Less than sign
>	Greater than sign
≤	Less than or equal to sign
≥	Greater than or equal to sign

## CHAPTER ONE

### 1.0 INTRODUCTION

#### 1.1 Background Information

Tanzania has approximately two million pigs of which 82% are owned by smallholders (Maziku *et al.*, 2017; URT, 2017a). About 84% of smallholder farmers in the country keep one to four pigs, whereas 10% keep five to nine pigs and only a few (4%) keep 10 – 14 pigs (URT, 2012). As it is the case in other Sub-Saharan African (SSA) countries more than 80% of pig enterprises in Tanzania are kept under the traditional farming system (Kimbi *et al.*, 2015). However, pig density differs across the regions whereby over 60% of domestic pigs in Tanzania are reared in Southern Highlands regions (Wilson and Swai, 2014). According to the United Republic of Tanzania (URT) survey report, Mbeya is the leading region with 713 063 pigs, followed by Tabora and Ruvuma regions with pig populations of 117 178 and 116 689 respectively (URT, 2017b).

Pig industry in Tanzania has been evolving gradually due to growth in human population, urbanization, and income (Michael *et al.*, 2018). The industry managed to provide income and protein sources of food to over 190 000 households in 2017 (URT, 2017a). It contributes to about 1.9 percent of Gross Domestic Product (GDP) at the production level and 5.3 percent at the market which is used for domestic consumption (URT, 2017a). According to Tanzania livestock master plan, the sector has the capacity to cover the production-consumption deficit of 8 000 to 1 350 tonnes in the year 2025 (Maziku *et al.*, 2017). However, despite these contributions to people's livelihoods and food security, infectious diseases, such as African Swine Fever (ASF) are the major constraint affecting the production and development of the sector.

Occurrence of ASF is associated with risk practices such as feeding of swill and illegal movement of animals within and between countries (Misinzo *et al.*, 2012). Currently there is no effective vaccine available to prevent ASF. The disease has a huge economic implication on reduction of the marketable output, reduction of pork and its meat supply, wastage of inputs, cost of disease control, human health impact, animal welfare and trade restriction (Bennett and Kitching, 2000). Parallel to this, previous studies such as those of Saka *et al.* (2010); Etter *et al.* (2011); Komba *et al.* (2014); Chenais *et al.* (2017) reported on economic implications of ASF on pig mortality, low pork's price, loss of business, loss of employment particularly in commercial sector, trade restriction and the cost of disease control. Furthermore, mortality in pig population and trade restriction has a consequence on food security in many countries particularly in areas where pork is an important source of dietary protein (Costard *et al.*, 2009).

Pig value chain involves activities from production to final consumption. The research work in pig value chain in Tanzania such as that of Katole (2012), indicate that there are four major pig value chain strands. The first strand involves pig producers and consumers whereby, pig keepers sell pig meat slaughtered at home. The second strand involves pig producers who sell live animals to retailers who sell fresh, fried and roasted pork to the final consumers. The third strand involves producers who sell the animals to wholesalers. The wholesalers slaughter and sell meat to retailers who finally sell roasted pork to consumers. The fourth strand is the longest strand including all the actors and activities from first to third strands and pig collectors who transport pig from the farm to traders. Following these strands and networks that link production systems, marketing channels and consumers, a contact network may be created and become a source for transmission of contagious disease such as ASF (FAO, 2011). Possibilities of occurrence of ASF in the pig value chain may have tragic implications on pig enterprises that may lead to enterprise

closure. It is imperative therefore to explore main risk practices for transmission of ASF and its economic implications on people who are affected in order to provide new insights and inform value chain stakeholders accordingly so as prevent or reduce the incidence of the disease cases.

### **1.1.1 African swine fever epidemiology**

African swine fever is caused by Deoxyribonucleic acid (DNA) virus that belongs to the genus *Asfivirus* of the family *Asfarviridae* (Dixon *et al.*, 2005). The disease was first reported in Kenya in the year 1921 when a high hemorrhagic fever that affects domestic pigs occurred (Montgomery, 1921). It remained endemic in African countries until in 1957 when it was first reported outside Africa (Portugal) due to contaminated food (pig swills) (Costard *et al.*, 2009; Penrith, 2015). The introduction of ASF in other European countries were controlled except Island of Sardinia (Italy) (Plowright *et al.*, 1994; Gallardo *et al.*, 2015 cited by Costard *et al.*, 2009). In Africa, ASF has occurred in most of the Eastern and Southern African countries. However, few outbreaks have been reported in Botswana and Namibia in 1999 and 2009, respectively (Simulundu *et al.*, 2017), Zimbabwe in 1993 and 2015 (Van Heerden *et al.*, 2017) and no information is available for Lesotho, Ethiopia, Somalia, Chad and Eritrea (Sanchez- Vizcaino *et al.*, 2009). The disease was reported in Democratic Republic of Congo (DRC) and the Republic of Congo in 2015, in Central part of Africa. Other outbreaks have been reported in Senegal, Nigeria, Benin, Togo, Burkina Faso, Ghana and Cameroon during 1996 to 2012 in West Africa (Brown *et al.*, 2017).

### **1.1.2 Affected species and clinical manifestations**

Domestic pigs are the only animal species that is naturally infected by African Swine Fever Virus (ASFV) while warthog and bush pigs act as its natural reservoir hosts and

they do not show any clinical signs (Sanchez-Vizcaino, 2006). In domestic pigs, the disease is characterized by high fever, loss of appetite, hemorrhages on the skin of ears, abdomen and legs, bleeding from the nose or rectum and mortality rate of up to 100% within 2-10 days (OIE, 2011). The disease does not affect human health.

### **1.1.3 Virus transmission and resistance**

The ASFV usually enters into disease free regions as a result of feeding pigs with uncooked pork waste products from ships and aircrafts (Gallardo *et al.*, 2015). After introduction of ASFV into an area, the virus may be transmitted directly during contact between infected and susceptible pigs, consumption of infected meat, by the bites of infected *Ornithodoros moubata* ticks and through contaminated materials and objects (Penrith and Vosloo, 2009). The ASFV is highly resistant to low temperatures and inactivated by pH < 3.9 or > 11.5 in serum medium (OIE Terrestrial Manual, 2012). The virus has ability to survive for long periods of time and spread over great distances in blood, faeces, infected tissue, uncooked or undercooked pork products (FAO/ILRI/AU, 2017).

### **1.1.4 Clinical and laboratory diagnosis of ASF**

Under clinical diagnosis, the disease depends on virulence of the virus. The high virulent isolates produce peracute or acute hemorrhagic disease while moderate virulent isolates produce sub acute and low virulent produces chronic forms. Parallel to this, morbidity and mortality varies from high to low virulent. In peracute cases, mortality in pig population can reach 100% without any clinical sign within 1-3 days after exposure to the virus. It is followed by the acute case with mortality rate that approaches 100%, fever (40.5°C - 42°C) and often death occurring within 6-13 days or up to 20 days. Susceptible pigs develop reddish lesions on skin, ears and abdomen. Also, abortion may occur to pregnant

sows and only virus carriers can survive the infection (OIE, 2011). The mortality rate for subacute form depends on age of affected population whereby younger pigs have higher rate (70%- 80%) and older pigs experience lower mortality rate < 20% (USDA, 2013). Mortality is typically low in pig populations which have been affected with low virulent virus (chronic form).

African Swine Fever may be confused with diseases and/or conditions such as Classical Swine Fever (CSF), Erysipelas, Aujeszky's disease (pseudorabies) in younger swine, Salmonellosis, Pasteurellosis, Porcine Reproductive and Respiratory Syndrome (PRRS). Therefore, it is good to base on laboratory test for accurate diagnosis of the cause of death in domestic pigs. In laboratory, tests are performed to determine the presence of ASFV including virus isolation, antigen detection through Direct Fluorescent Antibody (DFA) testing, Enzyme- Linked Immunosorbent Assay (ELISA), ImmunoFluorescence Assays (IFA) and polymerase chain reaction (PCR) tests (FAO/ILRI/AU, 2017). According to World Organization for Animal Health, ELISA is the prescribed test for international trade (OIE, 2011). However, PCR provides higher sensitivity and specificity than other alternative methods for antigen detection. Also, PCR is recommended when animals are dying from a highly virulent virus (Fasina *et al.*, 2010).

#### **1.1.5 Prevention and control of ASF**

The prevention of ASF is based on the enforcement of strict sanitary measures (Sanchez-Vizcaino, 2006). These measures include limiting people and vehicles to areas where pigs are kept, ensuring that workers and other visitors, such as veterinarians are disinfected before entering the premises. Others include daily sweeping, routine washing of pens with water and soap, application of disinfectants to washed and dry-cleaned materials, prompt disposal of dead animals and boiling of swill before feeding the pigs (FAO, 2010).

Furthermore, several control measures could be adopted during ASF outbreaks. These include quarantine, ban of all animal movements, culling or slaughter of animals, proper disposal of the carcasses and infected material by deep burial. Other control measures include application of restrict importation policy on pig products, proper disposal of waste products from aircraft or ship coming from endemic countries and disease surveillance for early detection (Penrith *et al.*, 2009; FAO/ILRI/AU, 2017).

### **1.1.6 Occurrence of ASF in Tanzania**

In Tanzania, ASF outbreaks were reported in 1962, 1987 and 1988 in Mbeya, Arusha and Kilimanjaro regions (Wambura *et al.*, 2006). After absence of the disease in more than a decade, repeated outbreaks commenced in 2000 (Misinzo *et al.*, 2014). In this case, ASF outbreaks were reported in different regions including Dar es Salaam, Mbeya, Arusha, Kigoma, Mwanza, Morogoro and Coast in 2000 to 2009. Other outbreaks followed between 2010 and 2012 in Mbeya, Iringa, Dar es Salaam, Rukwa and Morogoro regions (Misinzo *et al.*, 2012). The control of ASF has been difficult due to absence of vaccine and disease transmission through sylvatic cycle (warthog and soft tick transmission) and domestic cycle (transmission within pig population) in Eastern African countries (Misinzo *et al.*, 2014). Moreover, little information is known on the value chain operations, associated risk factors, and financial implication of ASF in people livelihood and food security.

## **1.2 Problem Statement and Study Justification**

African swine fever is the major constraint to the growth of pig industry in Africa, part of Asia and Europe (Fasina *et al.*, 2012a). The occurrence of ASF outbreaks causes high mortalities in pig populations and trade restrictions. In Europe total economic losses of

ASF outbreaks between 2007- 2012 have been estimated to be 2.3 trillion TZS<sup>1</sup> (one billion US\$) with more than 600 000 pigs destroyed (Rassow, 2014). In Africa, ASF is endemic in more than 22 countries in Sub Saharan Africa (SSA) with mortality losses of 30% to 50% of pig populations (FAO/ILRI/AU, 2017). For instance, the disease was estimated to cause annual losses of up to 2.09 billion TZS (US\$ 910 836.70) in Nigeria (Fasina *et al.*, 2012b). Lack of biosecurity at farm level is among high risk factor associated with ASF outbreaks (FAO/ILRI/AU, 2017). Besides, the absence of vaccine and complexity of the value chain with many actors performing different activities have made the disease control more difficult (Dione *et al.*, 2016).

Several initiatives have been made in order to prevent and control of ASF. In March 2013, the African Union's Inter African Bureau for Animal Resources, the Food and Agriculture Organization of United Nations (FAO) and International Livestock Research Institute (ILRI) collaborated to prevent and control ASF in Africa (FAO/ILRI/AU, 2017). The implementation was based on improving organization of the pig farming, identifying and mitigating the risks throughout the pig value chains. However, networking in pig value chain contains risk hotspots that contribute to transmission of infectious diseases such as ASF (FAO, 2011). According to Dione *et al.* (2016) value chain actors in transporting, slaughtering and collecting nodes contribute to high risk followed by inputs and supply nodes. On the other hand, processing, wholesale and consumption nodes represented the lower risks. Majority of pig farmers/producers suffer more losses during ASF outbreaks and panic to sale at low prices (Dione *et al.*, 2017). Moreover, the greatest losses are usually imposed on poorer producers who are less likely to implement effective prevention and control strategies (Edelsten and Chinombo, 1995).

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<sup>1</sup> 1USD = 2300 TZS

However, the expansion of the pig sector and an increasing trend of ASF occurrences and its transboundary nature has led Tanzania and other East African identified as a high priority area for disease. Therefore, because of the importance of the disease, the Eastern African Swine Fever Working Group (EA-ASF-WG) held a meeting in Dar es Salaam in 2015 to discuss control strategies for ASF in Eastern Africa countries. They agreed on strengthening ASF diagnostics, supporting regional laboratory, capacity building, information sharing and assessment of pig value chain operations in each country (FAO, 2015). Hence considering knowledge of the pig value chain in Tanzania, there is dearth of information on the value chain practices that are related to occurrence of ASF and impact on farmers. Therefore, this study aimed to determine risk factors related to ASF outbreaks and economic implications using a value chain approach. The study findings could inform strategic planning on the prevention, control and eradication program of the disease in Tanzania and other Eastern Africa countries.

### **1.3 Objectives of the Study**

#### **1.3.1 Overall objective**

The overall objective of this study is to assess the risk factors and determine economic implications of ASF in Songwe and Ruvuma Regions using value chain approach.

#### **1.3.2 Specific objectives**

The specific objectives of this study are as indicated hereunder:

- i. To map out the pig value chain in Songwe and Ruvuma regions;
- ii. To determine risk factors in production and marketing channels that contributes to occurrence of ASF; and
- iii. To determine financial losses associated with ASF in pig value chain in the study areas.

### **1.3.3 Research questions**

The following research questions guided the study:

- i. What are the pig value chain activities and how are the actors in the pig value chain related?
- ii. What are the risk factors related to ASF occurrence within pig value chain?
- iii. What are the financial losses of ASF on actors within the chain?

### **1.4 Organization of the Thesis**

This thesis is organized into seven chapters. Chapter one presents a general background of the study, problem statement and justifications of the study and research questions. Chapter two reviews the literature on the study specifically, theoretical and empirical reviews, analytical and conceptual framework in determining risk factors and estimating economic implications. Chapter three describes the methodology employed in the study. Chapter four presents the introduction, methods, results and discussion for objective number one as a publishable manuscript. Chapter five presents the introduction, methods, results and discussion for specific objective number two for second the publishable manuscript. Chapter six presents introduction, methods, results and discussion for specific objective number three as publishable third manuscripts. Chapter seven presents conclusion and recommendations.

## **CHAPER TWO**

### **2.0 LITERATURE REVIEW**

#### **2.1 Theoretical and Empirical Review**

##### **2.1.1 The economic theories governing the study**

There are two theoretical frameworks governing this study; assessment of disease risk using value chain analysis and assessment of the profitability of the firm (theory of firm). In the first scenario, the value chain consists of many actors who perform different activities that link production systems, marketing and customers. The networks and linkages in the value chain may constitute a contact network that provides opportunities for the transmission of contagious diseases such as ASF (FAO, 2011). Therefore, it is possible to assess value chain operations to identify hotspot areas. In this regards an understanding of the risk practices along the chain was required to map the entire value chain. The latter provided framework for determining how people manage domestic livestock animals and their products.

In the second area, the theory of the firm state that “a firm exists and make a decision to maximize profit”. However, there are several ways that animal disease affects the productivity and profitability of the firm. This includes impact on the reduction of the marketable output, reduction of pork and its meat supply, wastage of inputs, cost of disease control, human health impact, animal welfare and trade restriction (Bennett and Kitching, 2000). Therefore, estimating financial losses of ASF disease provided justification for prevention and control of disease that aims at maximization of profit and sustainable development of the industry.

### **2.1.2 Value chain concept and analysis**

The concept of the value chain in economics is not a new discipline and has been advanced in the body of literature. The value chain has been used to map out commodity flow within sectors from the early 1960s to the 1970s (Zamora, 2016). It followed by highlighting competitive advantages within and outside business networks (Fearne *et al.*, 2012), then applied more in agricultural market systems until 2005 when it was applied in livestock systems (Rich and Perry, 2011). Value chain analysis of any commodity has four main components. First, it systematically maps actors and the flow of products from production to end consumers. Second, it highlights the governance of the value chain of which is important in assessing power relationships in the chain. Third, it examines the impact of upgrading in quality, product design, new markets and diversification. Finally, value chain analysis can play a key role in identifying the distribution of benefits and actors in the chain. This implies that through the analysis one can determine who benefits from participation in the chain and which actors could benefit from increased share and support (Jaligot *et al.*, 2016).

Several studies have applied the value chain approach in analysis of agricultural products. Sumari (2017) conducted a study to determine high-value market opportunities for smallholder vegetable farmers in Arusha Region. Based on the literature, contract, standard and grading are characteristics of high-value markets. Descriptive analysis of value chain actors, binary logistic regression and SWOT analysis were used in the study. The results shown that age, sex, household, education level and occupations had high influence on vegetable production output. The participation in high value markets were determined by farming experience, tomato yield, cabbage yield, onion yield and distance to the market. Capability of vegetable farmers to participate in high-value market depend on knowledge and skills in vegetable production, land size, availability of water for

irrigation, access to inputs and extension services. Lastly, the presence of good climate and training opportunities from various organizations is high required.

Magabe (2016) assessed economic analysis of sesame value chain in Masasi District Mtwara, Region Tanzania. Specifically, the study aimed to identify structure and functioning, determine gross margin and factors affecting profitability along sesame value chain. Both qualitative and quantitative methods were employed. The findings show that key actors were input suppliers, farmers, traders, commission agents and exporters. Trader had relative higher gross margin than farmers. Factors influencing profitability depend on household's education level, age, marketing information and extension serviced. Therefore, the study recommended on availability and accessibility of market information, training intervention, land intensification and value addition of sesame. Similarly, a study by Kisanga (2015) examined the profitability and marketing chain of rice value chain in Kahama District Shinyanga Region whereas traders had relative higher gross margin than farmers.

A study by Laibuni and Omiti (2014) analysed the market structure and price of Irish potato in Kenya. The study has shown that Irish potato markets are oligopolistic in nature implying that only a few participants (rural brokers, urban brokers and transporter) have the market power. There is a barrier to entry at urban market centers where brokers provide link between wholesalers and retailers. In many cases transporter and brokers determine the price of the market for each potato consignment. Also, long-run price transmission proportions range between 25% and 59% which indicate spatial arbitrage conditions in the market. The study recommended on facilitation and upscaling of market information sharing and provision of incentives to encourage public-private partnership in

storage, distribution and marketing. Further, efforts should be made to facilitate arbitrage through the improvement of storage and physical market infrastructure.

### **2.1.3 Review of studies in livestock value chain analysis**

Alarcon *et al.* (2017) map the Nairobi beef, sheep, goat system structure and flows to identify deficiencies and vulnerabilities in the system. Mapping analysis was done in three different dimensions (people and product profiling, geographical and temporal mapping). The study found that 44% to 55% of beef supply flows through local terminal markets and 54% to 64% of total supply is controlled by small ruminant markets. Many informal chains were identified, with independent livestock, and meat traders played key role in the system. Geographical and temporal analysis revealed that large markets increasing their market share in low season. Although, large processing and partly integrated companies operate in high quality infrastructures, but up to 60% of their beef supply depend on informal markets. Also, these companies involved value chain addition, reaching high end markets but also dominating the distribution of the products. On the other hand, about 73% of the low season supply of small ruminant markets flow through large informal market. Lastly, the lack of traceability and control of animals was found in all chains.

Carron *et al.* (2017) used value chain framework analysis to understand animal and product flow, governance and sanitary risks in broiler meat systems in Nairobi, Kenya. The findings revealed that about 60% of broilers were supplied by one large company to farmers mainly through agro vet shops. Broiler meats from integrated companies were sold in high end retailers and their low value products were channelled through independent traders to customers in informal settlements. Small scale farmers slaughter the broilers on the farm and sell carcasses to retailers through brokers while farmers in informal settlements reported selling their broilers live to retailers directly. The sanitary

risks identified were lack of biosecurity, cold chain and access to water, poor hygiene, lack of inspection at slaughter slab, and limited health inspection in markets. Large companies and brokers were identified as dominant groups in market information, dissemination and price setting.

Kadigi (2014) researched marketing and upgrading opportunities in the indigenous beef cattle value chain. The study applied various participatory approaches and questionnaires survey to map the value chain, assess profitability and identify issues from short term intervention. The finding confirmed that profit margins are distributed very unequally and through the use of Information Communication Technology (ICT) system like mobile phone information can be used as a solution to lack of information. Producers obtain the lowest price and profit margin while the largest share of gross margin is earned by retailers such as butcheries and beef shop owners. Parallel to this, another study by Chuwa (2010) conducted an analysis on the chicken value chain in Singida and Dar es Salaam regions. Data were analysed by using SPSS to generate descriptive statistics such as mean, range, frequencies and percentages as well as cross tab and correlation coefficients. Marketing margin and profit margins along chain were also estimated. The study results indicated local chicken value chain was characterized by small scale operations at all nodes, high prevalence of diseases, low productivity per bird, poor facilities for handling and transporting live chicken and limited value addition. Price margins were found to vary among actors. Retailers were found to obtain higher profits than other actors.

#### **2.1.4 Review of previous studies in pig value chain analysis**

Kimbi *et al.* (2015) assessed characteristics of smallholder pig production systems in Tanzania and identify key issues needed for improvement. The characteristic of pig farmers in terms of mean farm size and number of pigs per household were  $2 \pm 2.7$  and

4.9 ± 4.2 pigs respectively. The large categories of pig herd structures were breeding females followed by piglets. Pig farmers practice three main type of pig management system, namely total confinements, semi confinement and free range. This management system varies significantly ( $P < 0.01$ ) by socio-economic factors such as education status, herd size, land size of animals. Therefore, improvement of pig sector should be made on agricultural farming system, local available resources for pig production and socio-economic circumstance of pig farmer.

In addition, Kimbi *et al.* (2016) assessed smallholders pig marketing system in Tanzania. The authors involved two cross sectional and longitudinal research design. The results shown that major participants were pig farmers who play role of producer and buyers, traders of live pig and pork and pork consumers. Pig farmers sold about 70% of their pigs to traders and 30% to other farmers. Marketed pig had small weight compared to their age. In general pig marketing system was dominated by informal channels which limit the performance and development of pig sector.

Pig production constraints of rural based small-scale farmers was identified by pig farmers in Iringa Region Tanzania. Farmers reported on unavailability of animal feeds, inadequate animal health, inadequate extension service and disease. Pig diseases perceived to be important were mange, worm infestation, hind limb paralysis, abortion, cysticercosis and diarrhoea (Karimuribo *et al.*, 2014).

Chiweka, (2012) performed the economic analysis of smallholder pig production in Mbeya and Mbozi districts of Mbeya Region Tanzania. Specifically, the study focused on the technical efficiency and profitability of keeping pig under free range and confinement production system. The results indicated that the return to pig smallholder under the

confinement production was high compared to free range system with the mean technical efficiency of 0.53 and 0.42 per farmer respectively. The level of efficiency was determined by education level, breeds of pig used and farmer access to extension service. Moreover, the profit per farmer was higher for the confinement production system. Therefore, pig farmers are recommended to keep pigs under a confined production system.

Other research work by Katole (2012) analyzed profitability along the pig meat value chain in Morogoro and Dar es Salaam regions in Tanzania. Data were analyzed using descriptive statistics, profit margin analysis and regression analysis. The results revealed that the pig value chain was characterized by little value addition, small scale operations and weak horizontal and vertical coordination among actors in the chain. Profit margin analysis indicated the variation of annual profit among actors with the highest profit obtained by retailers followed by producers, wholesalers, and assemblers obtained the least profit margin. The results of regression analysis showed that experience in piggery enterprise, labour man days, location of producers and contacts with extension officers were the main factors with significant influence on profitability of the pig business at the farm level. However, this study did not look on the role of the pig value chain in spreading and maintenance of ASF, therefore, this current study covered this gap to provide insight on disease risk and economic implications on actors in pig value chain.

#### **2.1.5 Value chain approach to animal diseases**

Value chain analysis in animal disease has been recently adopted in assessing disease risk and implications of diseases on each actor for appropriate planning strategies of prevention and control of animal diseases. Rich *et al.* (2009) used value chain analysis to find out the effects of disease on different stakeholders in a chain. The authors adopted

Kaplinsky and Morris's (2001) methods together with semi structured interviews and focus group discussions to assess impact of Rift Valley Fever (RVF) disease among chain stakeholders in Kenya. The results have shown that RVF outbreak causes food insecurity, lower milk production, abortion and income losses, livestock movement bans and incurred costs associated with maintenance of unsold stocks. Moreover Rich *et al.* (2009) applied value chain analysis on Highly Pathogenic Avian Influenza (HPAI) disease in Nigeria to identify critical control points of disease entry and spread and also explored relationships with breeder and hatchery operators. The results indicated that economic incentives faced by chain actors relative to commercial trading practices strongly contribute to the entry and spread of disease. Thus, the current study analysed pig value chain in order to determine the risk factors and points along pig chains at which mitigation is critical. In addition, the study aimed at understanding how the pig value chain operates in order to ensure that not only the animal health but also safety of the meat from the farm to the final product is attained.

## **2.2 Analytical Frameworks**

### **2.2.1 Logistic regression analysis**

Logistic regression model enabled test models to predict categorical outcome variables with two or more categories. The independent variables can either be categorical, continuous or mixed in one model. Generally, the association and/or the relationship between dependent and independent variables are determined by the Odds Ratios (OR) and confidence intervals for various factors in the final model (Pallant, 2007). Previous studies applied logistic regression analysis in assessing the risk factors of ASF in smallholder pig production in Sub Saharan Africa. For example, in Uganda, it was found out that improper disposal of pig carcass, presence of wild animals and farmers sourcing drugs from stockists were positively correlated with ASF outbreak (Dione *et al.*, 2017)

while the presence of an abattoir in farm community and presence of infected pig farm in neighborhood were found significantly related to ASF outbreak in Nigeria (Fasina *et al.*, 2012a). Therefore, in the present study logistic regression analysis was adopted to determine whether other risk factors are associated with ASF outbreaks in Songwe and Ruvuma regions of Tanzania.

### **2.2.2 Spreadsheet modelling techniques**

The spreadsheet model is a mathematical model which allows a decision maker to perform sensitivity analysis by repeating calculation to test how the decision might change with different assumptions (Marsh, 1999). Parallel to this description, Bennett and Kitching (2000) developed spreadsheet model that can provide herd level information on production losses due to livestock diseases. The authors mentioned seven areas of focus when studying economic impact of animal diseases. These include reduction in animal production, reduction in the quality of output, wastage of inputs, cost of disease control, human health impact, animal welfare impact and trade restriction. In addition, veterinary services play great role in preventing and treating diseases meaning that lack of veterinary services has an effect on animal production as well. Another study by Rushton *et al.* (2012) applied spreadsheet model to estimate economic impact of foot and Mouth diseases (FMD) in China, India, Asia, Africa and Europe. The study categorized production losses as direct losses and vaccination cost as indirect losses. It was found out that in China 24% of 6.1 trillion TZS (US\$ 2693 million)<sup>1</sup> were direct losses and 68% of 5.4 trillion TZS (US\$ 2 350 million)<sup>2</sup> indirect losses. The recent research work of George (2017) in ruminants used a spreadsheet model to estimate economic impact of Contagious Caprine PleuroPneumonia (CCPP) and Peste des Petits (PPR) in pastoral communities in

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<sup>1</sup> 1 USD = 2300 TZS

Ngorongoro and coastal districts of Tanzania. However, there is limited study that has analysed economic implications of ASF disease using a spreadsheet model.

### **2.2.3 Gross margin analysis**

Gross margin (GM) analysis is widely used in farm management to assess enterprise profitability (Akhilomen *et al.* 2015; Omobepade, 2015). According to Johnsen (2003) GM is defined as the difference between the values of an enterprise gross income and variable costs. The advantage of GM analysis is that it is easier to calculate as well as to understand. However, GM analysis has a limitation as it does not take into account the value of capital good or fixed cost. Despite this limitation, GM analysis has been commonly adopted by many experts and researchers in the agriculture and livestock field. Aheisibwe *et al.* (2017) assessed the profitability of apple enterprises under smallholder farming in Kabale, Kisoro, Kanungu and Rukungiri districts in Uganda. The study found out that the GM of apple enterprises in Kabale and Kanungu districts have a positive ratio of return on investment of 1.5 and 1.7 respectively. Kisoro and Rukungiri districts had a negative ratio of return on investment of 0.9 and 0.3 respectively.

Moreover, there is the research work of Musimu (2018) that examined the economics of smallholder common beans production in Mbeya, Tanzania. The result revealed that an average gross margin 309 214 per acre TZS of common beans was profitable and contributes significantly in income generation and employment creation. On the other hand, crop pests and diseases, unreliable rainfall, the high price of farm inputs, unreliable markets, shortage of land, price fluctuation and low capital were major challenges faced beans production in the study area.

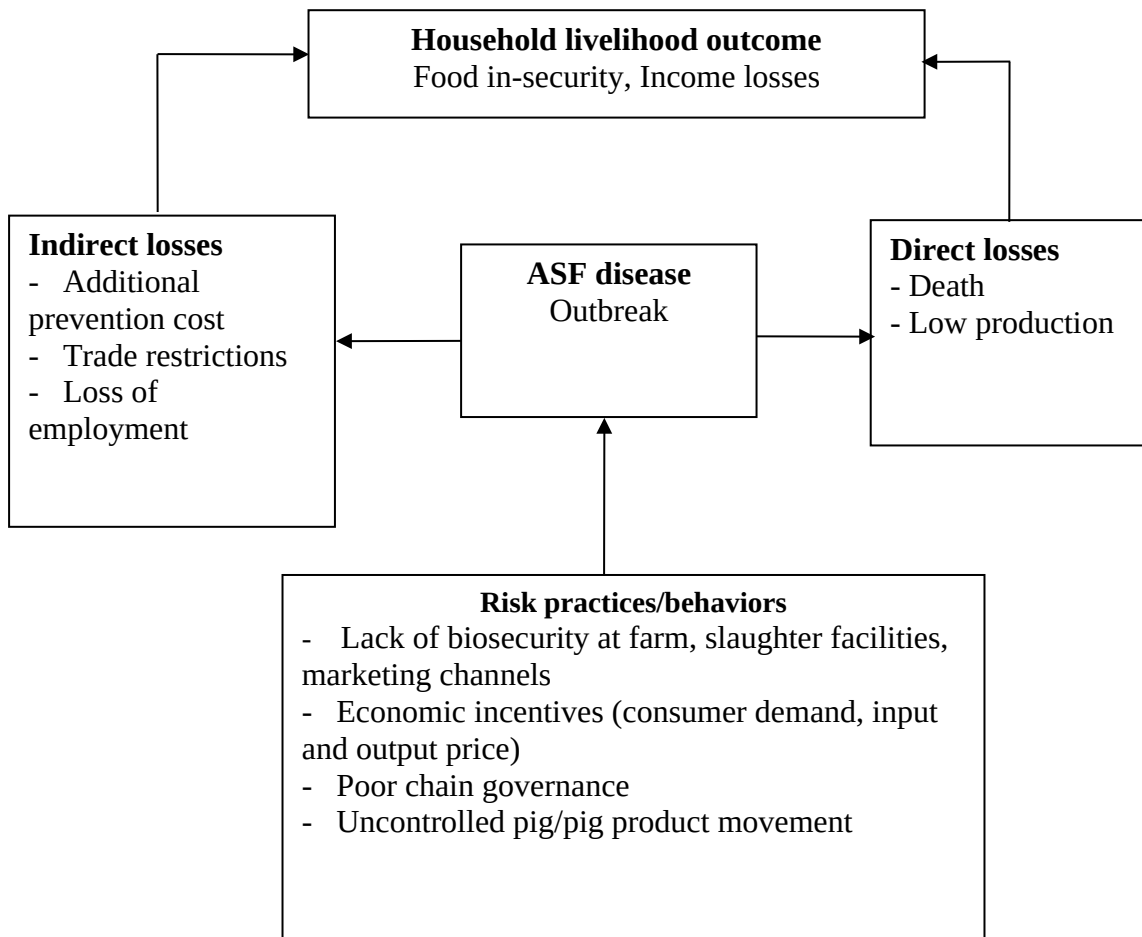
Other, research work of Daniel (2015) assessed Irish potato value chain to identify potential areas for interventions towards income for various actors in Njombe Urban and Wanging'ombe districts. The study found that GM was high for processors followed by traders and less on farmers. Regression analysis revealed that only 34% of variation in Irish potato GM were due to gender, farm size, age, farm location, income and irrigation. Lack of market information, low price, high transaction cost, and market distance were the major challenge facing farmers. Therefore, interventions should focus on these challenges so as establish profitable Irish potato value chain in the study areas.

The research work of Chiweka (2012) performed gross margin analysis on smallholder pig farmers. The GM per farmers was 290 141 TZS and 55 019 TZS for confinement and free-range production systems respectively. On the contrary, the current study was aimed to predict the indirect losses incurred by pig traders due to trade restrictions during ASF outbreaks under the assumption that trade restriction has an effect on the profitability of pig enterprises. Therefore, in this study, GM analysis was estimated in order to assess the profitability of pig traders of which the calculated value was referred to as indirect losses.

### **2.3 Conceptual Framework**

The research work of Katole (2012) and Chiweka (2012) developed the conceptual framework on production profitability and technical efficiency respectively for smallholder pig production. However, the conceptual frameworks on the effect of animal diseases (ASF) on pig production were not developed. The present study assumed that risk practices/behaviours from production, transportation, and marketing to consumption and waste disposal lead to ASF outbreak. Occurrence of ASF is the function of lack of bio-security at farm level, slaughter facilities, marketing channels, economic incentives (consumer demand, input and output price), poor chain governance (lack of inspection

and poor marketing rules and regulations) and uncontrolled live pigs/products movement. As indicated in Figure 2.1, the economic implications of ASF outbreak include both direct losses such as animal death and low production and indirect losses such as additional prevention cost, trade restriction and loss of employment. Both direct and indirect losses affect household's livelihood outcome in terms of income losses and food insecurity.



**Figure 2.1: Conceptual framework of the study**

## CHAPTER THREE

### 3.0 MATERIALS AND METHODS

#### 3.1 Description of Study Design and Areas

A cross sectional study was conducted in Songwe and Ruvuma regions of Tanzania. In Songwe, two Districts of Momba and Songwe were involved while in Ruvuma, Mbinga Urban and Songea Rural Districts were involved. Additionally, the areas were purposively chosen based on a high density of pig population (URT, 2017b), different animal production management and history of ASF outbreaks.

#### 3.2 Sampling Procedures

##### 3.2.1 Sample size determination

The sample size for pig producers was determined by the number of household interviews needed to obtain the estimates using Kothari, (2004) equation;

$$n = \frac{z^2 pq}{d^2} \dots\dots\dots (1)$$

Where;

n = Sample size (Number of households)

z = 1.96 corresponding to 95 confident interval and significant level  $\alpha$  at 5%

p = Estimated prevalence of disease (50%)

q = (1- P)

d = Permissible error 5%

Therefore, from given formula n = 384. A contingency of 26% to account for non-responses and incomplete data was added resulting to a final sample size of 484.

### **3.2.2 Pig producer sampling**

A multi stage sampling procedure was adopted in three stages. The first stage, four districts were purposely selected based on ASF history cases and pig population density. The second stage involved selection of villages. A total number of 19 villages were selected in collaboration with livestock field officers in respective districts. In the third stage, Livestock field officers provided lists of pig producers within study areas followed by random selection of households which keep pigs. Thereafter, the proportion technique was used to obtain the number of pig farmers in each village whereby 35% from list of producers were interviewed. Respondents were obtained through computer generated numbers using Randomizer software.

### **3.2.3 Pig trader sampling**

Since there were no physical markets for pigs, selection of traders was based on known information, accessibility and availability of traders during data collection (Mtimet and Baker (2013). Snowball sampling techniques was used to obtain traders within study areas. The information about first trader came from field officer in villages thereafter, the same trader was used to identify other fellow traders one after another for interviews. Thus, a total number of 28 pig traders were obtained from all surveyed districts.

## **3.3 Data Collection**

### **3.3.1 Secondary data**

In order to assess pig value chain in study areas, the secondary data were collected from different sources such as Sokoine National Agricultural Library, District Veterinary offices, National Bureau of statistics, Ministry of Livestock and fisheries Development, and Food and Agriculture Organization reports. These data were used to give insights on the ground situation.

### **3.3.2 Primary data**

Primary data were collected at household level and from livestock field officers. Household data were collected using structured questionnaires designed to collect both qualitative and quantitative data. Independent questionnaires were designed for pig producers and pig traders. Open Data Kit (ODK) was used to collect data. The questions in ODK were written in English and translated into Swahili during interview sessions. Semi structured key informants guide was used to interview livestock field officers. Moreover, direct observation methods were used to assess chain operation and performance.

## **3.4 Statistical Data Analysis**

### **3.4.1 Analysis of pig production and marketing practices**

Data analysis was done using Statistical Package for Social Sciences (SPSS)<sup>®</sup> version 25. Data were summarized using descriptive statistics including percentage, median and frequency tables to describe general characteristics of key actors in pig production and marketing nodes. For qualitative data thematic analysis was used whereby specific themes from qualitative research questions were deduced.

### **3.4.2 Logistic regression analysis**

The logistic regression analysis was performed in SPSS to establish relationship between variables. Initial screening of explanatory variables was performed using Univariate regression analysis. All significant variables from univariate analysis were included in multivariate analysis based on backward elimination method to produce the best fit model. Separate statistical analysis was performed for each region.

The probability of disease to occur was given by the following equation;

$$P(y_i = 1) = \frac{e^{\beta_0 + \sum_{j=1}^k \beta_j X_{ij}}}{1 + e^{\beta_0 + \sum_{j=1}^k \beta_j X_{ij}}} \dots\dots\dots (2)$$

Variables are;

X<sub>1</sub> = Introduction of new herd,

X<sub>2</sub> = Disease presence in neighbour farm

X<sub>3</sub> = Presence of warthog

X<sub>4</sub> = Presence of tick

X<sub>5</sub> = Farm visitor

X<sub>6</sub> = Sharing of boar

X<sub>7</sub> = Sharing of farm tools/equipment

X<sub>8</sub> = Improper disposal of waste product

X<sub>9</sub> = Feeding swill,

X<sub>10</sub> = Farm near slaughter slab

X<sub>11</sub> = Free ranging practice

X<sub>12</sub> = Kitchen leftover

β<sub>X<sub>1</sub> - X<sub>12</sub></sub> = Coefficients for explanatory variables

β<sub>0</sub> = Constant term

k = Number of independent variables

i = stratum

j = Number of observations

**(a) Assumptions****i. Independent error**

This error occurred when all outcome groups are separate from each other. In this study, the independent error was detected using Durbin Watson test. The decision rule for independent error is the p value less than 0.05.

**ii. Presence of linearity**

This refers to linear relationship between explanatory variables and outcome variable. ANOVA test was used to assess the model whereby the decision rule for linear relationship is the p value less than 0.05 for ANOVA test.

**iii. Absence of Multicollinearity**

Multicollinearity describes a situation of which one or two independent variables are highly correlated. The Variation Inflation factor (VIF) was used to identify correlation between variables whereby the rule of thumb for multicollinearity is a VIF of 5 or greater.

**iv. Lack of influential outliers**

The outliers are data that differ greatly from majority of data set. The interquartile range was used to determine the extreme value of the outliers by multiplying the interquartile (IQR) range by 1.5. If subtract  $1.5 * IQR$  from the first interquartile any data value that are less than former quartile value considered as outliers. Similarly, if we add  $1.5 * IQR$  from the third interquartile any data value that are greater than former quartile value considered as outliers.

### 3.4.3 Direct losses due ASF on pig producers

Bennett and Kitching (2000) spreadsheet model was adopted to determine direct losses due to pig mortalities and abortion. Parameters used included mortality rate, prevalence of ASF, herd size, value of live animal, number of aborted pig and value of aborted pig. Therefore, direct losses were calculated by the following equations;

$$\text{Direct losses} = \text{Mortality} + \text{abortion} \dots\dots\dots (3)$$

$$\text{Mortality losses} = m_r \times P_r \times n_h \times L_a \dots\dots\dots (4)$$

$$\text{Abortion losses} = N_u \times V_u \dots\dots\dots (5)$$

Where;

$m_r$  = Mortality rate (%)

$P_r$  = Prevalence of ASF (%)

$n_h$  = Number of herd size

$l_a$  = Value of live animal

$N_u$  = Number of aborted pig

$V_u$  = Value of aborted pig (TZS)

The estimated values of live pigs were 50 000 TZS for a piglet and weaner, 120 000 TZS for a grower, 200 000 TZS for a fattener/breeder, 400 000 TZS for an adult sow and 300 000 TZS for an adult boar (own survey, 2018). Mortality rate used was 100% (Ouma *et al.*, 2018) and 50% prevalence for unknown population in study areas. Lastly independent t-test at 95% confidence interval was used to compare mean financial losses between Songwe and Ruvuma regions. The decision rule was that the impact was considered statistically significant if the p-value is less than 0.05 for the t-value.

### 3.4.4 Indirect losses due ASF on pig traders

In this study an assumption was made in order to calculate indirect losses due to ASF on pig traders. The study assumed that traders could lose the same amount of profit due to trade restriction by government during outbreaks. Therefore, profitability levels of pig traders were estimated using Gross margin (GM) analysis method.

- (i) The Gross margin was calculated according to the formula equation 6 by Johnsen (2003)

$$GM = TR - TVC \quad \dots\dots\dots (6)$$

Where;

GM = Gross margin (TZS/Unit),

TR = Total revenue (TZS/Unit)

TVC = Total valuable cost (TZS/Unit)

### (ii) Assumptions in fixed cost

Some assumptions were considered in order to estimate the profit of traders. The fixed costs such as costs for livestock tools/equipment and the value for land were assumed to be constant due to the reason that these costs were not categorized as separate entity for the pig business.

## 3.5 Limitation of the Study

The main limitation of the present study was related to lack of record keeping by pig producers and pig traders. Therefore, the responses depended mostly on respondent ability to recall past events. Also, pig producers and traders were using different measurements to measure inputs. This required more conversions to get correct measurements (kilogram).

## CHAPTER FOUR

### **Manuscript 1: The role of pig production and marketing value chain in occurrence of African Swine fever in Songwe and Ruvuma regions, Tanzania.**

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#### **Abstract**

In recent years, the pig industry in Tanzania has faced frequent occurrence of outbreaks of African swine fever (ASF). However, there is inadequate information on the pig value chain operation in relation to occurrence of ASF. This study aimed at mapping pig value chain and assesses its contribution to the occurrence and spread of ASF in Tanzania. A cross sectional study was carried out in Songwe, Momba, Songea and Mbinga districts of Tanzania. Study districts were purposively selected based on the density of pig population, differences in production systems and history of ASF outbreaks. A total number of 484 pig producers and 28 traders were involved in the study. Random sampling was used to select pig producers. Pig traders were selected using snowball technique.

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Structured questionnaires were used to collect data on pig management and production practices, veterinary services, pig marketing practices and biosecurity measures using Open Data Kit (ODK) software. Semi structured interviews were conducted with key informants on perceived risk practices that are related to ASF outbreaks, challenges and recommendations on ASF prevention and control measures. Observation method was used to assess structure, facilities and practices within the pig production chain. The main actors in the pig production chain were pig producers, assemblers, wholesalers and retailers. Unknown stock source (30%), poor husbandry practice such as free ranging (5%), poor management of waste products (73%) and poor handling of feed (73%) were risk practices in the production node. Transportation nodes operated under high risk due to frequent movements and pick-ups of  $\geq 30$  pigs per trip. The results demonstrated that different actors operate in the pig production, distribution and marketing chain. Each node operated under low biosecurity measures, and poor infrastructures that are likely to contribute to occurrence of ASF. There is need to improve good husbandry, marketing and infrastructures to increase production while ensuring pork safety.

**Keywords:** African Swine Fever; Animal protein; Pig value chain; Tanzania

**Status:** Published in East Africa Science Journal

#### **4.1 Introduction**

Globally, pig production is increasingly driven by the demand for animal protein in the market. The pig industry accounts for 118.7 million tonnes of pork meat of which a large amount is produced in China, European Union countries, the United States of America, Brazil and Russia (FAO, 2018a). The world pork meat market has increased by 1.4% from 8.1 million tonnes in 2017 to 8.3 million tonnes in 2018 (FAO, 2018b). In Sub-Saharan Africa (SSA), South Africa accounts for 26% of the pig production followed by Nigeria (19%) and Uganda (12%) (FAOSTAT, 2010). Available statistics indicate that there are approximately 2 million pigs in Tanzania (URT, 2019). The consumption of pork meat is increasing due to the price of substitute meat products, increasing wealth,

and growing population in both rural and urban centers (Kimbi *et al.*, 2016). Parallel to this, Tanzania's pig industry has the capacity to grow and reduce a production-consumption deficit for pork from 8 000 to 1 350 tonnes in 2025 (Maziku *et al.*, 2017). Despite this rapid growth of the sector its economic contribution is threatened by outbreaks of African swine fever (ASF) (FAO/ILRI/AU, 2017).

African Swine Fever is an infectious disease and number one killer of pig populations (Wilson and Swai, 2013). The disease is caused by Deoxyribonucleic acid (DNA) virus that belongs to the genus *Asfivirus* of the family *Asfarviridae* (Dixon *et al.*, 2005). It is a major constraint in development of pig industry in Europe, Asia and Africa due to a high mortality rate of up to 100% in domestic pigs (OIE, 2011). In SSA, over 22 countries have reported ASF epidemics (FAO/ILRI/AU, 2017). The disease was first reported in Eastern African countries in 1921 (Montgomery, 1921). In the absence of a vaccine, ASF control has relied on culling/ slaughtering of pigs, proper disposal of carcasses, quarantine, sanitation and hygiene measures and education interventions (Penrith *et al.*, 2013).

The prevention and control of ASF depends on available information on chains operation and performance using value chain analysis (FAO, 2011; Dione *et al.*, 2016). The analysis describes the system dynamic, classifying interaction and linkages as well as assess the behavioral risk practices such feeding swill, farm visitors, sharing boars and free ranging which contribute to disease transmission (FAO, 2011). Understanding of the pig value chain, drivers and factors contributing to transboundary animal disease spread can contribute to designing of effective control strategies. Value chain refers to a full range of activities which are required to bring products or services from production, marketing channels to end consumers and final disposal after use (Kaplinsky and Morris, 2001) It can be classified based on two approaches: The first approach is based on the role of chain

governance and the second approach on coordination and operation of activities within chains. The former determines the rule of trade and who decides what to produce (producers' or buyers' chain) while the latter defines how people or actors in value chain perform and the decision they made (Fold and Larsen, 2008).

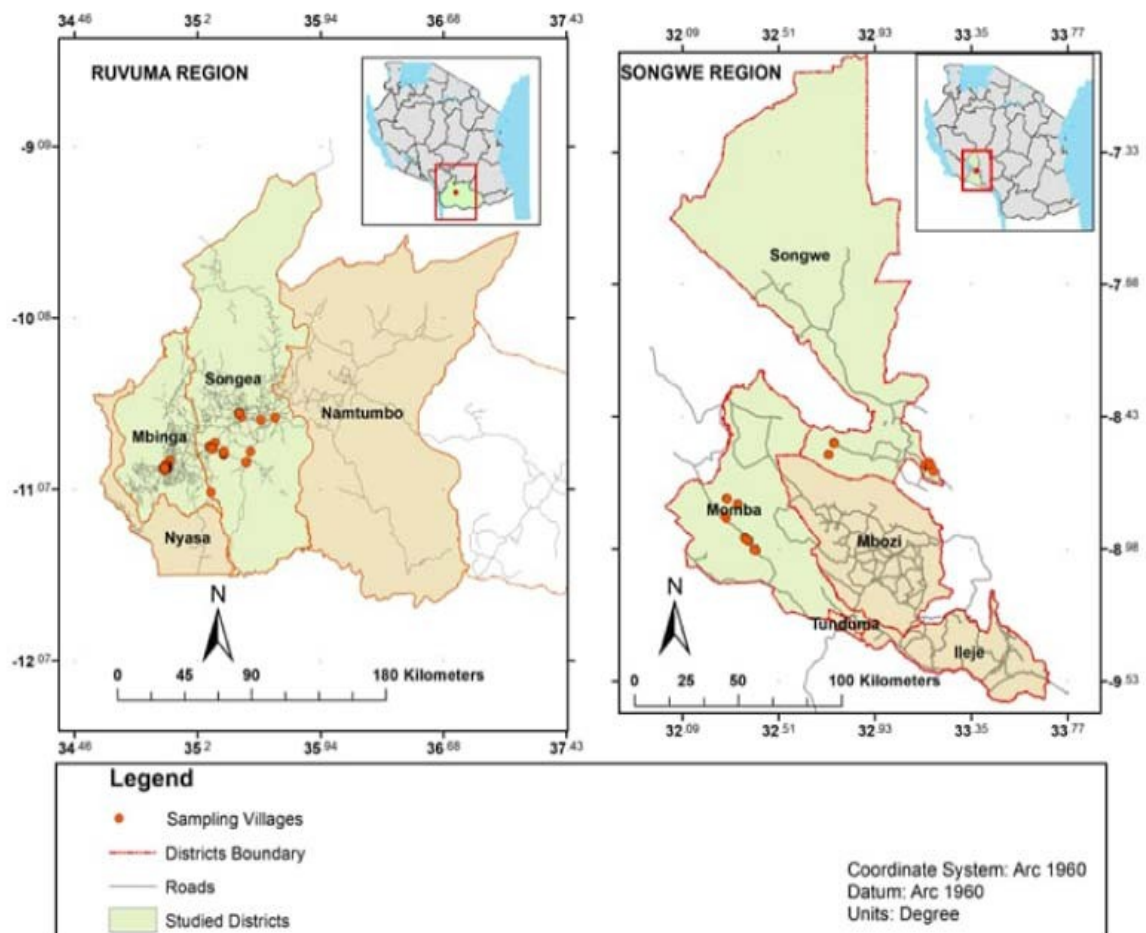
While previous studies in Tanzania have reported on ASF epidemiology and molecular identification of African swine fever virus (ASFV) genotypes circulating in different parts of the country (Misinzo *et al.* (2011); (2012); (2014); and Wambura *et al.* (2006); there is dearth of information on the role played by pig value chain operation in disease epidemiology. Such information could contribute in designing effective ASF disease management within the country. Therefore, the objective of this study was to map pig value chain and assess its role in the occurrence and spread of ASF in selected districts of Tanzania.

## **4.2 Materials and Methods**

### **4.2.1 Study area**

The study was conducted in Songwe and Ruvuma regions of Southern Tanzania. In Songwe two districts, Momba and Songwe were involved; while in Ruvuma, Mbinga and Songea districts were involved. The populations of Songwe, Momba, Songea and Mbinga districts were 133 692, 196 818, 173 821 and 353 683 respectively (URT, 2012) Crop and livestock production are the most important economic activities in these study areas. Additionally, the areas were purposively chosen based on different ecosystems of animal production, history of ASF outbreaks and high density of pig population. Songwe region has approximately 79 513 pigs (URT, 2015) and Ruvuma region has a population of 116 689 pigs (URT, 2017). There are five veterinary health services (consultation and drug outlets) within study areas. In Songwe district selected wards and villages were

Ifwenkenya ward (Ifwenkenya and Iyela villages) and Namkukwe ward (Namkukwe and Mheza villages); Momba district, Ikana ward (Ikana and Nyenjele villages) and Myunga ward (Namshinde and Mfuto villages); Songea district, Peramiho ward (Peramiho A village), Ngogosi ward (Namatuhi village), Kizuka ward (Nghahokora village), and Magagura ward (Magagura village); Mbinga district, Mbinga Mjini B ward (Misheni street), Luhuwiko ward (Luhuwiko A and Luhuwiko B streets), Bethlehemu ward (Mahela and Bethlehemu streets) and Lusonga ward (Ruvuma and Kihaha streets) (Fig. 4.1).



**Figure 4.1: Study areas**

#### 4.2.2 Study design and sampling

A cross sectional study was carried out in which data were collected from October to November 2018 in Songwe and Momba districts, and from June to July 2019 in Songea

and Mbinga districts. The sample size for pig producers was determined by the formula developed by Kothari (2004) i.e.  $n = z^2pq/d^2$  whereby  $n$  is the sample size,  $z$  is 1.96 corresponding to the 95% confidence interval level and significant level of 5%,  $p$  is the prevalence of disease which is estimated at 50% (Thrusfield, 2018),  $q$  is  $1 - p$ , and  $d$  is the permissible error of estimation (0.05). Therefore  $1.96^2 \times 0.5 \times 0.5 / 0.05^2 = 384$ . A contingency of 26% was added to account for non-responses and incomplete data was added resulting to a final sample size of 484 households keeping pigs. Since there were no physical markets for pigs in study districts, sampling of traders was based on known information, accessibility and availability of traders during data collection. Thus, a total number of 28 pig traders were obtained from all surveyed districts.

Prior information on ASF outbreaks distribution in the study areas was obtained from respective district veterinary offices. Livestock Field officers provided lists of pig producers within study areas that served as sampling frames for pig producers. In this study pig producers with and without pigs at the time of data collection were interviewed. Snowball sampling technique was used to obtain traders within study areas. The information about the first trader came from field officers in villages, thereafter, the same trader was used to identify other fellow traders one after another for interviews and the process was repeated until the point of thematic saturation was reached. The targeted pig trader populations were assemblers, wholesalers and retailers.

The value chain in this study was based on coordination and operation of activities within the pig production system. An assumption was made that operations and activities in pig value chain are independent and absence of command within chains (Wilson, 2015). In addition, this approach could enable assessment of risk practices in relation to transmission of disease within chains.

### **4.2.3 Data collection**

A semi-structured questionnaire was used to collect data from pig producers and pig traders. The questionnaire for pig producers focused on household characteristics, source of stocks, production system, production constraints, breeding type, herd size, feed materials, premises structures, management of waste products, training and veterinary services, and biosecurity measures. While the questionnaire for pig traders included questions on characteristics of pig traders, type of business, initial capital, source of stock, marketing prices, marketing distance, marketing constraints, management of waste products and biosecurity measures. Three research assistants were recruited and trained on study objectives and protocol. Software was used to collect data. The English version of a semi-structured questionnaire was translated to Kiswahili. The questionnaire was installed in the android mobile device with Open Data Kit (ODK) software. It was pre-tested in an area in Songwe district that was not involved in the actual study. Modifications were made to the questionnaire before been used for actual data collection. A single interview took approximately 30 minutes to complete.

Moreover, we interviewed district livestock officers (n=2) and field officers (n=8) as key informants. Furthermore, we directly observed the presence of veterinary services, water supply, means of animal transport, slaughter facilities, animal inspection, pig premises, presence of fence, ticks, warthogs, disposal of waste products and behavioral risk practices such as feeding swills, free ranging, farm visitors and sharing boars and farm equipment without disinfectant that could contribute to introduction and spread of ASF. These parameters were marked good practices as 1, poor practices as 2 and not applicable as 3.

#### **4.2.4 Statistical data analysis**

Data analysis was done using Statistical Package for Social Sciences (IBM SPSS) version 25<sup>®</sup> (IBM Corp, Armonk New York, USA). Data were summarized using descriptive statistics including percentage, median and frequency tables to describe general characteristic and graphical representation of key actors in pig value chain. For qualitative data thematic analysis was used whereby specific themes were deduced from qualitative research questions. Thematic areas addressed in this study include knowledge on risk practices that are related to ASF outbreaks, opinion on factors limiting the control of ASF and recommendations on ASF prevention and control measures.

#### **Ethical Approval**

The study was approved by the Sokoine University of Agriculture (reference number SUA/CVMBS//R.1/2018/2019/2). Permission to conduct the study was obtained from the respective district and village authorities. Informed consent was obtained from pig owners.

### **4.3 Results**

#### **4.3.1 Socio-demographic characteristics of pig producers**

A total of 484 respondents were involved in the study. Of these, 99 were from Songwe, 97 from Momba, 119 from Songea and 169 were from Mbinga. Of the total respondents, 45% were females and 55% males between minimum age 13 to maximum 85 years. Over 50% of pig producers had attained primary education as shown in (Table 4.1).

#### **4.3.2 Socio-demographic characteristic of pig traders**

A total of 28 pig traders were involved during data collection. Out of them, seven were from Songwe district, five from Momba district, 11 were from Songea and five were from

Mbinga districts. All five assembler traders were married males with minimum age of 27 and maximum 44 years, and four had acquired primary education. On the other hand, 21 retailer traders were males and two were females with age minimum of 17 years and maximum of 65 years”. Over 50% attended primary education and only two were not married. In order to start pig business, the minimum initial capital investment for selling pork meat was between 50 000 TZS and 200 000 TZS (Table 4.2).

**Table 4.1: Socio-demographic characteristics of pig producers in Songwe and Ruvuma regions, Tanzania**

Category	Variables	Songwe Region			Ruvuma Region		
		Songwe (n = 99) (%)	Momba (n =97) (%)	Total (N = 196) (%)	Songea (n =119) (%)	Mbinga (n= 169) (%)	Total (N = 288) (%)
Sex	Male	58.6	90.7	74.5	52.1	34.3	41.7
	Female	41.4	9.3	25.5	47.9	65.7	58.3
Age	Mean	40.2	38.1	39.2	44.1	46.2	45.3
	Median	37	35	38	41	44	40.5
	Std. Deviation	10	13	11.81	14.7	14.1	14.4
	Minimum	21	15	15	13	16	13
	Maximum	68	89	89	95	83	95
Marital Status	Single	2.0	4.1	3.1	13.4	10.7	11.8
	Married	90.9	91.8	91.3	77.3	68.6	72.2
	Widowed	5.1	3.1	4.1	8.4	18.3	14.2
	Divorced	2.0	1.0	1.5	0.8	2.4	5 (1.7)
Education status	Never attend school	16.2	12.4	14.3	1 (0.8)	5.3	3.5
	Informal school	-	1.0	0.5	1.7)	-	0.7
	Primary school	74.7	73.2	74.0	84.9	69.8	76.0
	Secondary school	8.1	13.4	10.7	9.2	20.1	15.6
	Tertiary education	1.0	-	0.5	3.4	4.7	4.2
Household size	1 - 5	33.3	41.2	37.2	62.2	65.1	63.9
	6 - 10	46.5	53.6	50.0	37.8	34.9	36.1
	11 - 15	14.1	3.1	8.7	-	-	-
	16 - 20	5.1	-	2.6	-	-	-
	21 - 25	0	2.1	1.0	-	-	-
	>25	1.0	0	0.5	-	-	-
Reason for keeping pigs	Income generation	67.3	93.0	78	92.13	81.5	85.5
	Reproduction	19.0	1.0	12	2.36	-	0.9
	Manure	1.4	1.0	1	5.51	16.6	12.3
	Domestic consumption	9.5	3	7	-	2.0	1.2
	Cultural	2.7	2	2	-	-	-

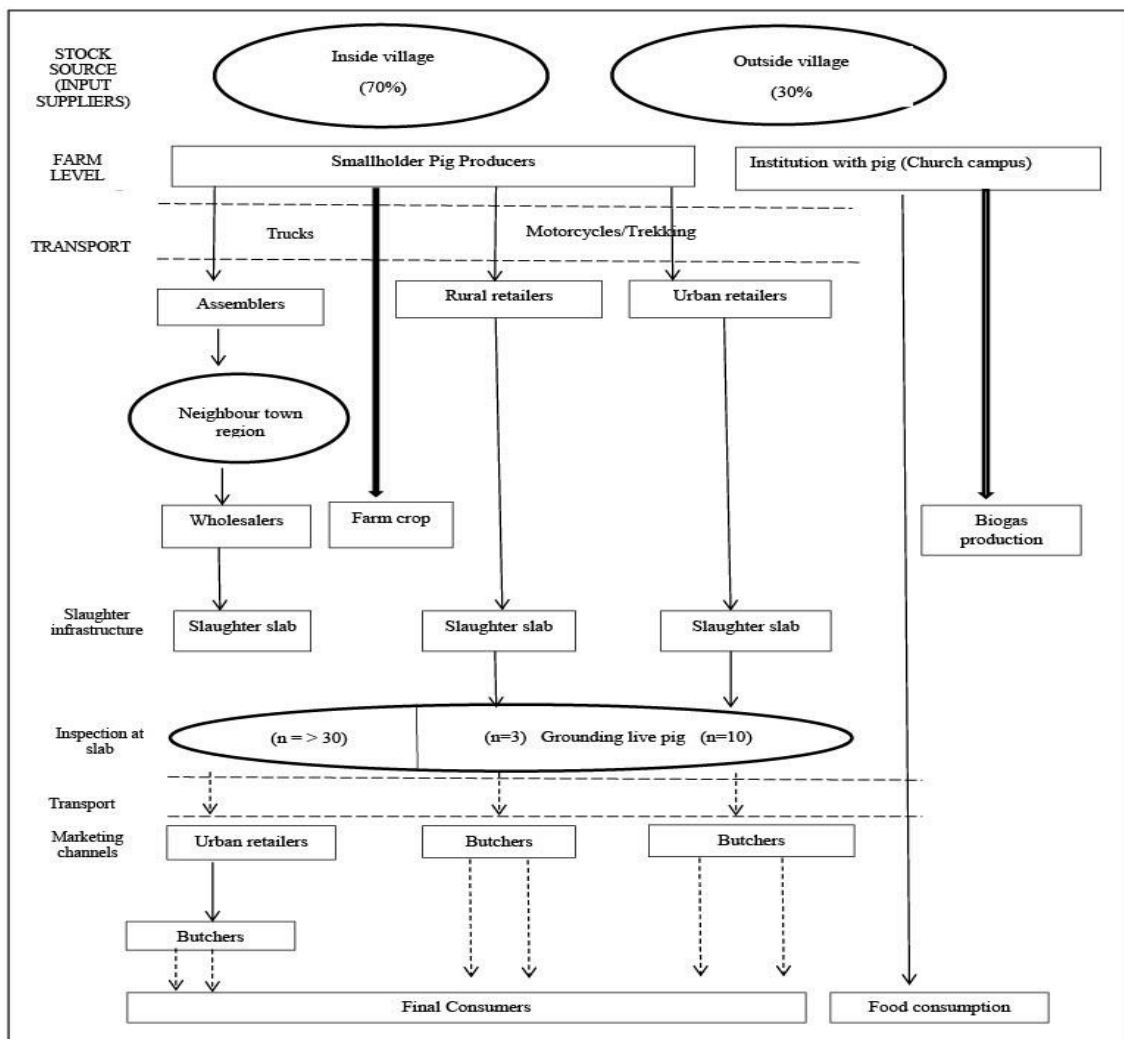
**Table 4.2: Socio-demographic characteristics of pig traders in Songwe and Ruvuma regions, Tanzania**

### 4.3.3 Main actors in pig value chain

Category	Variable	Songwe (n=7)		Momba (n=5)		Total (n=12) (%)	Songea (n=11) (%)
		(%) Assemblers (n= 2)	(%) Retailers (n=5)	(%) Assemblers (n= 3)	(%) Retailers (n=2)		
Age	Mean	35.5	30.6	35.7	30.5	32.7	37.5
	Median	35.5	30	35	30.5	31	39
	Std. Deviation	8.5	9	4.9	1.5	7.64	7.53
	Minimum	27	17	30	29	17	24
	Maximum	44	45	42	32	45	52
Sex	Male	100	80.0	100	100	91.7	100
	Female	-	20.0)	-	-	8.3	-
Marital status	Single	-	20.0	-	-	8.3	9.1
	Married	100	80.0	100	100	91.7	90.9
Education status	Never attended school	50.0	20.0	-	-	16.7	-
	Primary school	50.0	80.0	100	100	83.3	90.9
	Secondary school	-	-	-	-	-	9.1
Household size	1 - 5	50.0	80.0	66.6	50.0	66.7	63.6
	6 - 10	50.0	20.0	33.3	50.0	33.3	36.4
Initial capital investment	50 000 - 200 000	-	80	-	100	50	27.3
	250 000 – 500 000	-	20	-	-	8.3	72.7
	> 500 000 – 1 000 000	50	-	-	-	8.3	-
	> 1 000 000	50	-	66.7	-	33.3	-

Through the mapping process, it was found that the main actors involved in production, distribution and marketing were pig producers, assemblers, wholesalers, rural and urban retailers. The flow of products involved live pigs, raw pork, offal, heads, legs and pig's oil. Pig producers were involved in rearing pigs and selling directly to traders. Assembler traders were engaged in transportation of live pigs within and outside districts. The wholesale traders were involved in buying and selling pigs in large quantity from assemblers while retail traders were involved in buying live pigs in small quantity from pig producers, slaughtering and selling raw pork or roasted pork to end consumers (Fig. 4.2).





**Figure 4.2: Mapping of actors and flow of products in pig value chain in Songwe and Ruvuma regions, Tanzania**

- > Straight arrow shows the flow of live animals for selling and food consumption.
- - - - -> Interrupted arrow shows the flow of pork meat and offal heads, legs and pig oil.
- >** Bold arrow shows the flow of manure of which used for crop farming and biogas generation.

#### **4.3.4 Production node**

##### **Pig management and production practices**

Over 50% of pig producers reported to have acquired pig stocks from neighboring farms within study areas. However, it was found that producers in Songwe (7.1%), Momba (29.9%), Songea (5%) and Mbinga (12.4%) obtained pigs from outside villages and neighboring regions. Majority of pig producers in Songwe (93.9%), Momba (91.8%), Songea (79.0%) and Mbinga (81.7%) preferred to keep indigenous breed compared to pure breed, cross breed and exotic breed. Most of pig producers in Songwe (42.4%), Momba (34%), Songea (68.1%) and Mbinga (94.1%) owned about 1.00 acres to 2.00 acres for pig production. Semi confinement production system was observed in Songwe (44.4%) and Momba (68%) while Songea and Mbinga districts practice confinement production system (Table 4.3a).

It was found that women were source of family labour in Songwe (31%), Momba (28%), Songea rural (23%) and Mbinga (56%) while very few producers in Songwe (2 percent), Momba (3 percent), Songea rural (5 percent) and Mbinga (5 percent) reported that children were the one taking care of pigs. Poor implementation of biosecurity measures such as use of protective gears and washing equipment with disinfectant were reported in Songwe (75%), Momba (83%), Songea (40%) and Mbinga (46%). Moreover, it was found that, producers in Songwe (56%), Momba (41%), Songea (73%) and Mbinga (53%) managed waste products inappropriate by throwing away. Approximately pig producers in Songwe (35%), Momba (62%), Songea (3 percent), and Mbinga (14%) had not treated sick animals due to lack of veterinary services. Cooking of pig feeds was not common in Songwe (73%), Momba (73%), Songea (65%) and Mbinga (52%) (Table 4.3b).

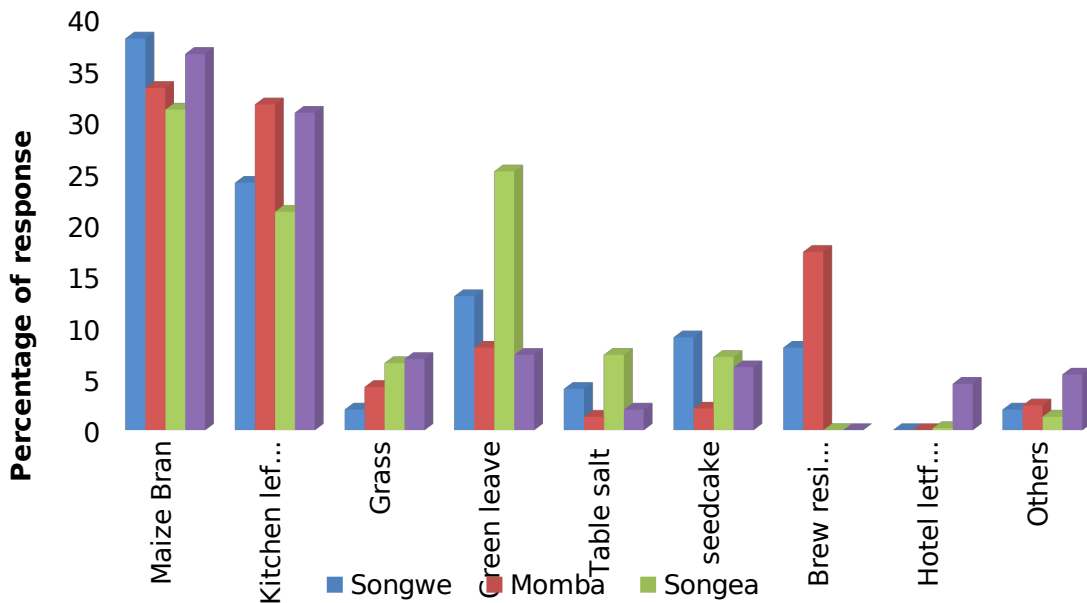
**Table 4.3a: Pig management and production practices**

Category	Variables	Songwe Region			Ruvuma Region		
		Songwe (n = 99) (%)	Momba (n =97) (%)	Total (N = 196) (%)	Songea (n =119) (%)	Mbinga (n= 169) (%)	Total (N = 288) (%)
Source of stock	Neighbouring farm	85.9	59.8	72.9	80.7	73.4	76.4
	Outside village	7.1	29.9	18.4	5.0	12.4	9.4
	Mission camp	-	-	-	11.8	11.2	11.5
	Family/relative	6.0	7.2	6.6	0.8	2.4	1.7
	Others	1.0	2.0	3.0	1.7	0.6	1.1
Breed type	Indigenous breed	93.9	91.8	92.9	79.0	81.7	80.6
	Exotic pure breed	2.0	3.1	2.6	7.6	2.4	4.5
	Cross breed	4.0	5.2	4.6	13.4	16.0	14.9
Herd size	0	14.1	17.5	15.8	26.9	17.8	21.5
	1- 4	44.4	32.0	38.3	48.7	62.7	56.9
	5- 9	20.2	27.8	24.0	14.3	10.1	11.8
	10 - 14	11.1	12.4	11.7	4.2	7.1	5.9
	15-19	2.0	3.1	2.6	2.5	0.6	1.4
	>20	8.1	7.2	7.7	3.4	1.8	2.4
Land Size	Do not own land	10.1	11.3	10.7	7.6	5.3	6.3
	1.00 - 2.00 acres	42.4	34.0	38.3	68.1	94.1	83.3
	> 2.00 - 4.00 acres	21.2	32.0	26.5	18.5	-	7.6
	> 4.00 _ 10.00 acres	14.1	17.5	15.8	5.0	0.6	2.1
	>10 acres	12.1	5.2	8.7	0.8	0.6	0.7
Production system	Confinement	41.4	6.8	34.2	95.0	100	97.9
	Semi confinement	44.4	68.0	56.1	3.4	-	1.4
	Free range	4.0	5.2	4.6	0.8	-	0.3
	Tethering	10.1	-	5.1	0.8	-	0.3

**Table 4.3b: Pig management and production practices**

Category	Variables	Songwe Region			Ruvuma Region		
		Songwe (n = 99) %	Momba (n =97) %	Total (N = 196) %	Songea (n =119) %	Mbinga (n= 169) %	Total (N = 288) %
Person responsible for caring of pigs	Husband	15.2	20.6	17.9	10.9	9.5	10.1
	Wife	31.3	27.8	29.6	22.7	51.5	39.6
	Children	2.0	3.1	2.6	5.0	5.3	5.2
	Both 1and 2	23.2	24.1	24.0	33.6	15.4	22.9
	All 1, 2 and 3	27.3	22.6	25.0	18.5	10.7	13.9
	Hired labour	1.0	0	0.5	2.5	3.0	2.8
	Himself/herself	0	1.0	0.5	3.4	0.6	1.7
	Others	0	0	0	3.4	4.1	3.8
Cleaning frequency	Daily	28.3	4.1	16.3	31.1	13.6	20.8
	Weekly	33.3	26.8	30.1	27.7	33.1	30.9
	Monthly	8.1	19.6	13.8	5.0	13.0	9.7
	Two/thrice a week	19.2	23.7	21.4	28.6	14.2	20.1
	Twice a month	1.0	2.1	1.5	2.5	3.0	2.8
	No cleaning	6.1	12.4	9.2	4.2	6.5	5.6
	Quarterly	0	3.1	1.5	0	3.6	2.1
	No specific time	4.0	8.3	6.2)	0.8	13.1	8.0
Disposal of waste products	Proper (Deep burial collecting waste, burning)	44.4	58.8	51.5	26.9	46.7	38.5
	Improper (throwing away, feed to pigs, disposal of dead pigs)	55.6	41.2	48.5	73.1	53.3	61.5
Boiling feed/ leftovers	Yes	27.3	26.8	27	35.3	47.9	42.7
	No	72.7	73.2	73	64.7	52.1	57.3
Wash/Use of protective gears	Yes	25.3	17.5	21.4	59.7)	53.8	53.3
	No	74.7	82.5	78.6	40.3	46.2	43.8
Animal treatment services	Yes	64.6	38.1	51.5	96.6	86.4	90.6
	No	35.4	61.9	48.5	3.4	13.6	9.4

Different feeds were fed to pigs in the study areas. Maize bran was highly used in Songwe (38%), brew residuals in Momba (17%), green leaves in Songea (25%), and hotel leftover in Mbinga (5%) (Fig. 4.3).



**Figure 4.3: Type of feed used by pig producers in Songwe and Ruvuma regions, Tanzania**

The common materials used to construct roof was grass thatched while timber was used on walls and floor (Plate. 4.1a, 4.1b, 4.1c 4.1d). Up to 18% pig premises were left open on the roof while 5 percent to 44% had mud floor within study areas (Fig. 4.5).



**Plate 4.1a: Peramiho village - Songea District**



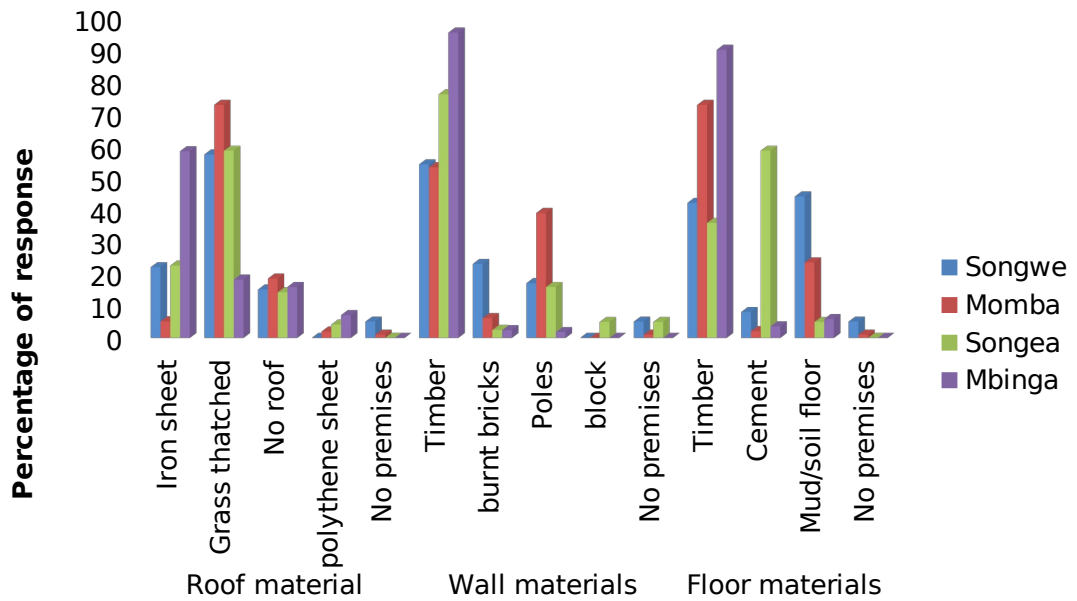
**Plate 4.1b: Magagura village - Songea District**



**Plate 4.1c: Nyenjele village - Momba District**

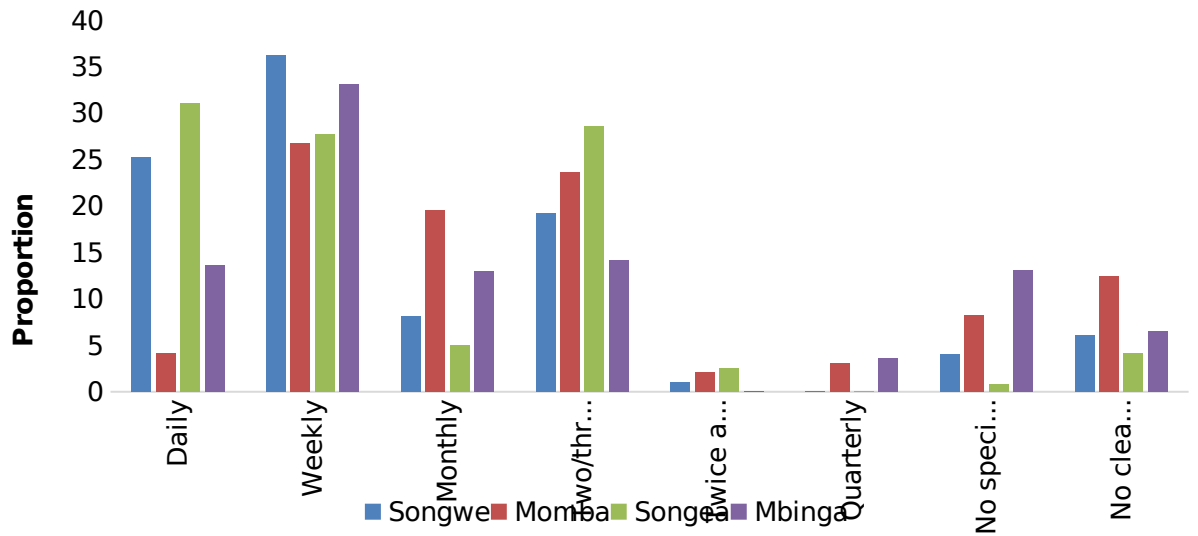


**Plate 4.1d: Misheni Street- Mbinga District**



**Figure 4.4: Type of materials used for pig premises in Songwe and Ruvuma regions, Tanzania**

Further, the analysis showed that in all districts less than 50% of pig producers used to clean pig premises on daily or weekly basis (Fig. 4.6).



**Figure 4.5: Routine cleaning of Pig premises in Songwe and Ruvuma regions, Tanzania**

### **4.3.5 Transportation node**

#### **Assemblers marketing practices**

All (5) surveyed assemblers adopted sole proprietorship form of business, they reported not to have business licenses. Two (2) assemblers lived within study areas and while the rest three (3) came from neighboring districts and towns in Mbeya and Njombe regions. Assemblers (n=5) purchased live pigs from more than five producers and transported them to neighboring towns/regions. Depending on pig weight, the price ranged between 50 000 TZS and 400 000 TZS. The residential assemblers reported to transport between 6 and 10 live pigs per trip while those from outside the districts transported large numbers of live pigs ( $\geq 30$ ) per trip. Both residential and non-residential assemblers hired trucks to transport purchased live pigs from study areas to pig slaughter slabs in the neighboring region/town/city. The assemblers reported to transport live pigs during night and spent an average of two hours in short distances of 70 to 100 kilometers and more than five hours in long distances of 396.3 kilometers or more. All assemblers reported not to observe biosecurity measures such as disinfecting the vehicles/trucks before loading and after unloading of animals during transportation (Table 4.4).

### **4.3.6 Marketing node**

#### **4.3.6.1 Slaughter slab practices**

Animal health inspections and slaughtering activities were conducted at slaughter slabs. It was observed that the slabs were open structures without facilities and with poor hygiene in Songwe and Songea districts. In Mbinga, the slaughter slab was found to be slightly improved with infrastructures and water facilities. Pig slaughtering activities were more active in urban areas than in rural areas. Also, it was observed that only few traders were in gumboots and white long clothes at slaughter slabs.

#### **4.3.6.2 Wholesalers and retailers marketing practices**

The distribution and marketing of live pigs and pig products involving wholesaler traders were not common in all study districts. However, it was mentioned by assemblers that wholesalers could be found at pig slaughter slabs in neighboring town/city/region including in Mbeya and Njombe regions. In all districts the retailer traders shared common practices. Majority of pig retailers (n=22) operated in sole proprietorship while a few operated in partnership. Retailer traders (n=7) had no business licenses, while 12 had business licenses. Traders reported to purchase live pigs from pig producers both within and outside their villages of residence. Retailers (n=13), purchased live pigs daily, slaughtered and sold raw pork or roasted pork. Depending on the distance, several means of transport including trekking/ motorcycle/bicycle and trucks were used to transport live pigs from farm to different destinations within the study districts. In all districts, retailers were purchasing at least one live pig. Besides, two retailers in Songwe, four in Songea and four in Mbinga reported to purchase more than one live pig and kept them at home before slaughtering. Slaughtering practices were conducted at slaughter slabs. It was observed that the slabs were open structures, without water supply and other equipment and had poor waste products management. It was observed that retailer traders (n = 4) were in gumboots and white overalls at slaughter slabs. The infrastructures and equipment used in butcheries and pork roast shops were of poor hygiene (unclean environment) as they could not protect pork meat from external contamination (Table 4.4).

**Table 4.4: Marketing activities and Practices in Songwe and Ruvuma Regions, Tanzania**

Category	Variable	Songwe (n=7)		Momba (n=5)		Total (N=12) No	Songea (n=11) No Retailers	Mbinga (n=5) No Retailers	Total (N=16) No
		No Assemblers (n= 2)	No Retailers (n=5)	No Assemblers (n= 3)	No Retailers (n=2)				
Business ownership	Sole proprietorship	2	4	3	2	11	11	5	16
	Partnership	-	1	-	-	1	-	-	-
Business license	Yes	-	-	-	-	-	7	5	12
	No	2	5	3	2	12	4	-	4
Residential Status	Within district/urban	1	5	-	2	8	11	5	16
	Outside district/urban	1	-	3	-	4	-	-	-
Source of stock	Both within and outside	2	5	3	2		11	5	16
Number of producers	>5	2	5	3	2	12	11	5	16
Number of live pigs purchased per day	1	0	3	0	2	5	7	1	8
	>1 - 5	0	2	-	-	2	4	4	8
	6 - 10	2	-	-	-	2	-	-	-
	>10 - 30	-	-	-	-	-	-	-	-
	>30	-	-	3	-	3	-	-	-
Means of Transport	Trekking/head	-	2	-	1	3	-	-	-
	Hired trucks/load vehicle	2	-	3	-	5	-	-	-
	Motorcycle /bicycle	-	3	-	1	3	11	5	16
Number of hours on road	30 – 45 mins	-	5	-	2	7	7	3	10
	1 – 2 hours	2	-	-	-	2	4	2	6
	>5 hours	-	-	3	-	3	-	-	-
Frequency Purchase	4-10 days/month	2	-	3	-	5	-	1	1
	30days/months	-	3	-	-	3	6	4	10
	Once in a week	-	2	-	2	4	5	-	5
Protective gears	Yes	-	-	-	-	1	3	1	4
	No	2	5	3	2	11	8	4	12

The respondents (livestock field officers) reported on poor husbandry such as free ranging as well as low biosecurity measures at farm level and marketing channels. In order to improve production and preventing disease outbreaks, application of livestock policy and bylaws within the chain is a necessity. The respondents mentioned presence of animal movement policy, bylaws against free ranging practices, inspection check points, and penalty for violation of by laws. However, it was claimed that monitoring and implementation of the bylaws and regulations was the major challenge. One respondent had this to say: *'During ASF outbreak in 2018, we caught a retailer trader selling pork that was not inspected by livestock officer in charge. We reported the case to the Police Station. However, the suspect won the case due to lack of strong evidence against him'* (FLO, Songea district). Moreover, the respondents reported that there were backyard slaughtering practices especially during ASF outbreaks. For instance, one respondent reported that *'I caught a trader who slaughtered at backyard and sold out pork unsuitable for human consumption but due to bureaucracy with long chain of procedures that trader was able to run away'* (FLO, Mbinga district). In addition, it was reported that the sources of disease outbreaks included farm visitors, animal movements and products from infected villages. One of the respondents had this to say: *'In order to ensure implementation of animal movement regulations; the Ministry of Livestock and Fisheries should consider delegating issuing of animal permit to Village Government Authority in order to control illegal movement of animals'* (Extension Officer, Songwe district).

#### **4.4 Discussion**

The findings from this study have shown that there are many actors in pig industry from production, distribution, marketing to consumers. Based on pig value chain performance within districts, the production was dominated by pig producers keeping one to four pigs. This

finding is consistent with census report on pig production in Tanzania (URT, 2012). Many pig producers owned small pieces of land ranging from one to two acres of which was considered to be enough space to keep one to four pigs for small scale production. An interesting finding was the fact that only one type of breed was kept by pig producers in all the four districts. Many preferred to keep indigenous breeds with a reason that they are less susceptible to diseases including ASF.

The production chain involving pig producers highlighted key information that could contribute to transmission of ASF. Outsourcing pig stocks from various places without considering the health status of pigs could have been the source of ASF introduction and spread in the four study districts. The ASF transmission through unknown sources has also been reported in previous studies in Uganda and Nigeria (Fasina *et al.*, 2012; Kabuuka *et al.*, 2014; Nantima *et al.*, 2015). It was found that practices such as free ranging system during dry season were common in rural areas compared to urban areas. Probably this observation could partly explain the spread of previous outbreaks by free roaming pigs in rural areas. This practice is similar with the characteristic of smallholder producers in Uganda (Dione *et al.*, 2017).

Other practices such as low biosecurity level in pig premises could contribute to introduction of ASF into un-infected pig herds. Pig premises were observed to be very dirty even those in which pig producers claimed to perform daily cleanliness since waste products were maintained nearby the farm. The open roof structures and others with mud floor have a high chance of exposing pigs to a number of infections. These findings are in agreement with those of Dione *et al.* (2017) in Uganda who reported that open pig premises exposed animals to predators and stray animals. Different feed types were used to feed pigs but yet there was poor handling of feed, use of dirty

equipment, and feeding of leftovers could be source of farm outbreaks. It seems that majority of pig producers have inadequate knowledge on implementation of biosecurity measures suggesting that purposive education and awareness campaigns should be conducted. Similar findings were reported in Tororo and Busia districts in Uganda and Busia and Teso district in Kenya (Nantima *et al.*, 2015).

In our study districts, pig marketing was dominated by male traders implying that there is high disease risk in marketing channels since males are less likely to implement biosecurity measures. This finding is supported by a study in Uganda that reported a belief by males that biosecurity measures such as cleanliness are women responsibilities (Dione *et al.*, 2020).

Small capital investment to purchase live pigs was observed to be the main concern of pig traders in marketing activities. Along with this, lack of license among pig traders was common in all the study districts. The absence of business license especially in rural areas result in lack of data on pig marketing channels for industry planning and development as well as in intervention against ASF.

Transportation of live pigs during night hours could be the source of disease transmission from infected areas to uninfected areas. This finding is consistent with what was found in a previous study in Uganda which reported on behavior of traders to avoid inspection and as a loophole for transporting infected pigs (Dione *et al.*, 2017). Moreover, the practice of collecting live animals from more than one farms/producers, loading and unloading of animals without cleaning and disinfection of vehicles could be sources of disease transmission within and outside the districts. Similar observations have been reported in Kenya and Uganda (Lichoti *et al.*, 2017). Meanwhile, a long

period of time used during transportation carried high disease risks of infected pigs to affect health pigs as previously reported in Uganda (Dione *et al.*, 2016).

Marketing activities of pork meat and other products were more common in urban compared to rural areas meaning that marketing activities are economically driven by urbanization and income growth (Njuki *et al.*, 2010). On average, the urban retailers slaughtered 10 pigs daily compared to 3 pigs in rural areas. This is an indication that traders in urban areas practice more farm visit due to consumers demand. Additionally, this observation entail that the emerging towns and cities require strict measures to fight against ASF. This is because most towns and cities are targeted market for pork meat (Amar *et al.*, 2021).

Poor hygiene was observed in slaughter slabs whereby waste products discarded in open areas which could be the source of disease outbreaks (Asambe *et al.*, 2019) Apart from facilitating disease spread, unhygienic environment in slaughter slab, as well as roast shops and butchers, indicate that there is a high chance of consumers to end up with unsafe pork meat.

The key informants highlighted that behavior of traders to avoid animal inspection and slaughtering practice in the backyard played great role in the spread of ASF. This finding entailed the need to improve good husbandry in order to enhance productivity and meat safety. Meanwhile, field officers pointed out that among the factors that hinder control of animal movements at could be lack of direct power to livestock officers and extension officers regarding the animal movement permits. This weakened enforcement of animal movement control

has been attributed to spread of diseases in many countries of Africa and Middle East (Ogundipe, 2002). Recommendation on decentralized power in issuing the animal movement permits was given as a way forward in solving animal control movements. Parallel to this, quarantine of animals that are being moved between regions and animals introduced within regions should be emphasized in order to prevent the introduction and spread of diseases.

#### **4.5 Recommendations to Future Interventions**

Since there is no effective treatment available against ASF, prevention would be much achieved by enforcement of strict biosecurity measures. It is important to increase actor's awareness on risk practices such as free-ranging practice, sharing boars, feeding pork leftovers, and poor disposal of dead pigs to all actors involved in pig production and marketing. The formation of pig business associations should be encouraged to provide an opportunity to improve pig value chain operations and ensure access to market information. Moreover, improved availability and accessibility to veterinary services are likely to play major roles in reducing diseases outbreak through routine disease surveillance, training and extension services. Training should provide knowledge transfer on good husbandry such as confinement of pigs to avoid free-ranging practices associated with outbreaks. Lastly, it is important to improve infrastructures such as slaughter facilities not only to control disease but also to ensure meat safety.

The current study faced the following limitations: i) it was conducted when there were no ASF outbreak cases. Although its findings could inform chains operation and sources of ASF outbreaks, more attention should be given to pig chain performance during ASF outbreaks, ii)

the time interval is unlikely to have had influence on practices and there was no interventions implemented in the study areas during the period. However, we cannot account on unknown sources of changes in the practices and their implications such as exchanges of information among the actors/pig owners between the study sites, iii) lack of record keeping by pig producers and pig traders. Despite being able to capture production practices within the pig value chain; it was not possible to establish relationship between pig management and factors influencing pig productivity due to absence of records on different variables including the number of piglets born, number of births and age of sow.

#### **4.6 Conclusions**

The findings demonstrated that pig producers, assemblers, and retailer traders were operating in pig production, distribution and marketing chains in Tanzania. Each node performed under poor biosecurity measures, poor infrastructure and facilities which could contribute to introduction and spread of ASF. The transportation node carried a high disease risk due to many movements and pick-ups. There is need to improve good husbandry and marketing infrastructures to increase productivity and ensure pork safety. It is anticipated that overview information on chains operation and possible disease risk practices from this study will be used as inputs in the design of future ASF prevention and control measures in Tanzania.

#### **Conflict of Interest**

The authors declare that there is no conflict of interest.

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## CHAPTER FIVE

### **Manuscript 2: Risk Factors Associated with Occurrence of African Swine Fever in Pig Production in Songwe and Ruvuma Regions of Tanzania**

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**Abstract**

African Swine Fever (ASF) is a fatal disease of pigs which can spread within affected areas and introduced in new ones. The present study determined risk factors associated with the occurrence of ASF in Songwe and Ruvuma regions. A cross-sectional study was carried out in Songwe and Momba districts of Songwe region and Songea and Mbinga districts of Ruvuma region. A questionnaire was administered to 484 pig producers to obtain information on pig production, management and biosecurity measures. African swine fever outbreaks occurred mainly during the rainy season in three districts and dry season in one district. Risk factors for occurrence of the ASF outbreaks in Songwe region were sharing of boars ( $P < 0.01$ , OR= 7.05 and CI<sub>95%</sub>=1.78; 28.00) and sharing of farm equipment ( $P < 0.04$ , OR= 4.14 and CI<sub>95%</sub>=1.07; 16.09). In Ruvuma region, predictors for occurrence of the disease outbreaks were presence of bush pigs ( $P < 0.01$ , OR= 3.08 and CI<sub>95%</sub>=1.33; 7.14) and visitors access to farm ( $P < 0.01$ , OR= 2.38 and CI<sub>95%</sub>=1.23; 4.61). The government and other stakeholders in animal health management could focus on increasing number of boar supply, use of disinfectants for equipment, limiting visitors near pig premises and avoiding pig farming near reserved areas for feasible prevention, control and eradication of the disease in Songwe and Ruvuma regions.

**Keywords:** African Swine Fever, Risk, Pig, Tanzania.

**Targeted Journal:** Tanzania Veterinary Journal

## 5.1 Introduction

African Swine Fever (ASF) is a fatal disease of pigs caused by African Swine Fever Virus (ASFV) which is a member of the family *Asfarviridae* (Dixon *et al.*, 2005). Domestic pigs are susceptible to ASF with high mortality of up to 100% while warthogs and bush pigs are infected by the virus but do not show clinical signs (Penrith *et al.*, 2009). Globally, ASF was first described in Kenya in the year 1921 (Montgomery, 1921). Since then, it has become endemic to many African countries including Tanzania (Alcrudo *et al.*, 2017). The virus can be transmitted by sylvatic cycle, pig-tick cycle and domestic cycle (Costard *et al.*, 2009). These transmission pathways vary from one country to another. The sylvatic and domestic cycles exist in the East and Southern African regions. Also, the sylvatic cycle is involved in Central Africa while in the Western African region only the domestic cycle has been described (Gallardo *et al.*, 2015).

Further, the transmission between domestic pigs has been identified in several areas with high pig density, high practice of free-range management system and low biosecurity level (Penrith *et al.*, 2013). In Tanzania, about 60% of domestic pigs are located in Southern Highlands (Wilson and Swai, 2014) and lack of biosecurity at the farm levels had resulted in disease transmission in many regions (Misinzo *et al.*, 2011; Sikombe, 2013). Considering transmission of ASFV, there is a need to understand the pig value chain operations and determine risk factors associated with the occurrence of the disease in the Southern Highlands of Tanzania to provide useful knowledge contributions for designing disease prevention and control strategies.

Experts and researchers in animal health have documented on risk factors related to the occurrence of ASF in Nigeria and Uganda. These include presence of wild animals, proximity to slaughter slabs, improper disposal of dead pigs, free range husbandry, feeding swill to pigs, farm visitors, restocking and presence of infected pigs in neighbouring farms (Fasina *et al.*, 2012a; Kabuuka *et al.*, 2014; Nantima *et al.*, 2015; Dione *et al.*, 2017; Asambe *et al.*, 2019). Parallel to this information, the present study was conducted to determine whether similar or other risk factors have effect on the likelihood of ASF outbreaks in Songwe and Ruvuma regions of Tanzania.

## **5.2 Materials and Methods**

### **5.2.1 Study areas**

The study was conducted in Songwe and Momba districts of Songwe region and Songea and Mbinga districts of Ruvuma region (Fig. 5.1). These areas keep pigs as their main livestock for income generation followed by local chicken, and goats. Households practice semi confinement and confinement production systems in Songwe and Ruvuma regions respectively. Women are the source of family labour and they feed pigs different feeds including maize bran, brewers waste, green leaves and leftover.

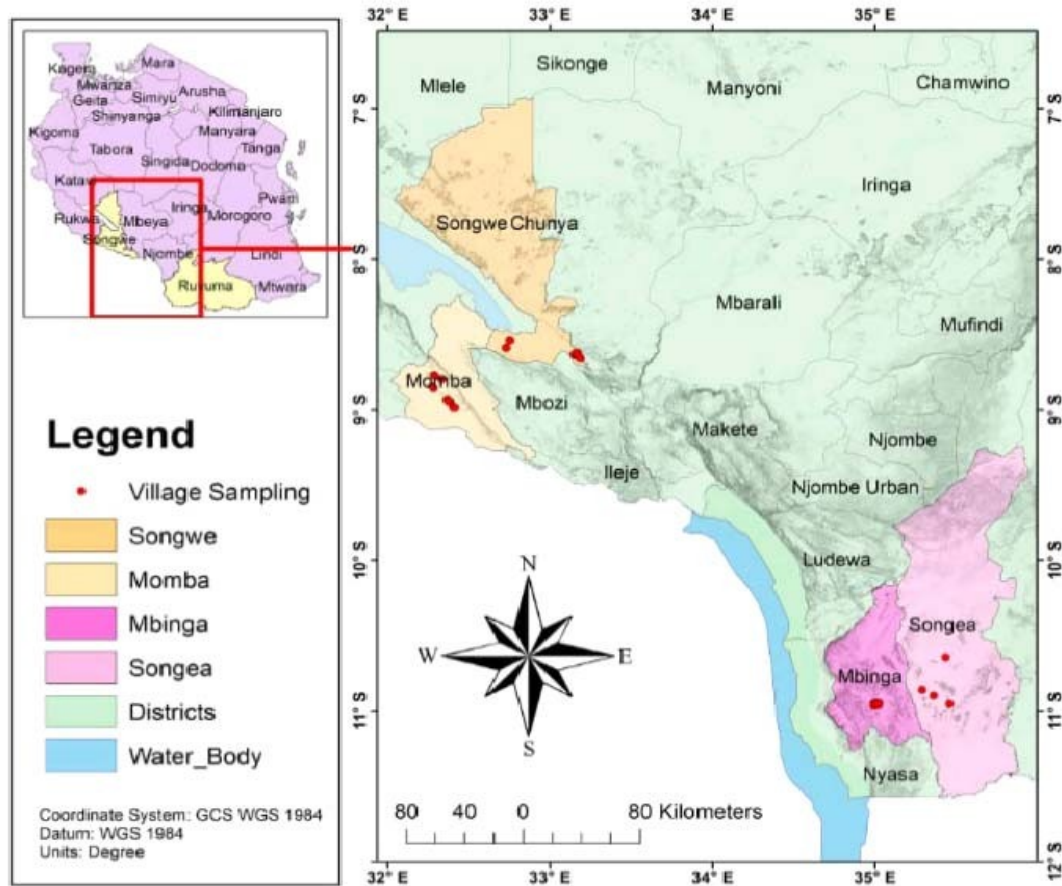


Figure 5.1: Study areas

### **5.2.2 Study design**

A cross sectional study was carried out in Songwe and Momba districts of Songwe region and in Songea and Mbinga districts of Ruvuma region. The target population was both affected and unaffected pig producers during ASF outbreak of 2017/2018. From the list of pig producers, a total number of 484 pig producers were randomly selected and interviewed.

### **5.2.3 Data collection**

A structured questionnaire was administered to pig producers within the study areas. Face to face interviews were conducted to obtain information on pig production, management and biosecurity measures. This study adopted ASF standard case definition from previous studies that involved smallholder pig production in Uganda (Dione *et al.*, 2014; Dione *et al.*, 2017). Pig producers were considered to be affected with ASF outbreak when they mentioned disease clinical manifestations among their pigs. These include loss of appetite, redness in ears and skin, weakness in legs and sudden death. Although, literature documented on high fever being among ASF clinical signs, in the study areas high fever was mentioned by only few pig producers.

### **5.2.4 Data analysis**

Statistical Package for Social Sciences (SPSS) version 25<sup>®</sup> (IBM Corp, Armonk New York, USA) was used to analyse data. Descriptive statistics were computed. Risk factor analysis was done by running logistic regression. Initial screening of explanatory variables was performed using Univariate regression analysis. This procedure helped to reduce variables with no association with outcome variable

(presence of disease). Variables associated with outcome at P value  $\leq 0.20$  were considered in multivariate logistic regression (Fasina *et al.*, 2012a). All significant variables from univariate analysis were included in multivariate analysis based on backward methods to produce the best fit model. Land size and herd size were identified as cofounders and retained if resulted in more than 10% change to the coefficient for any other remaining predictors. Goodness of fit of the final model was assessed using the Hosmer and Lemeshow test (Hosmer and Lemeshow, 2002). The model was indicated as a good fit with value greater than 0.05. In the final model the Odds Ratios (OR) and 95% confidence intervals for various factors at  $P \leq 0.05$  were calculated.

The basic assumptions that must be met for logistic regression model were considered and tested. These assumptions include independent error, linearity, absence of multicollinearity and lack of influential outliers.

### **5.3 Results**

#### **5.3.1 Demographic features of respondents**

A total of 484 households were visited for interviews in the following order; Songwe (n=99), Momba (n=97), Songea (n=119) and Mbinga (169). Out of 484 respondents, males were 266 (55%) and females were 218 (45%) of age  $\leq 85$ . Majority of respondents (80%) were married and three quarters of them (75%) had attended primary school. Approximately 390 (81%) of households had pigs in premises of which 239 (48%) had a herd size ranging from one to four pigs.

### **5.3.2 Experience and knowledge of ASF**

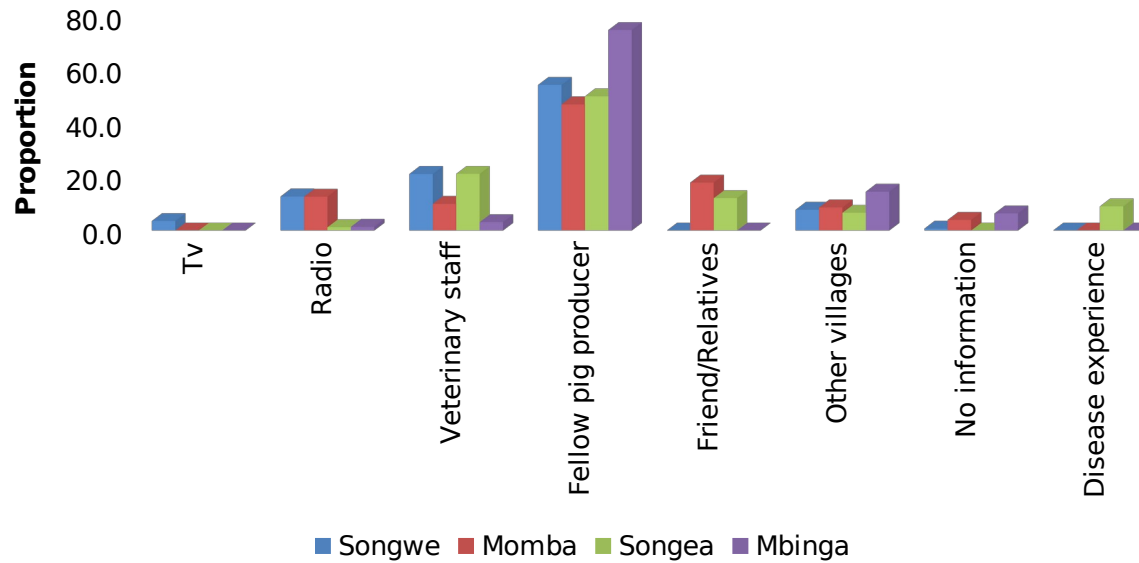
The findings revealed that many producers reported to experience an outbreak at farm level in Songwe (89%), Momba (98%), Songea (65%) and Mbinga (47%). Although many producers in Songwe (97%), Momba (98%), Songea (82%) and Mbinga (98%) were aware of ASF as an obstacle in pig production, they lacked knowledge on disease introduction and spread within and/or outside the village. Some producers believed that occurrence of ASF was due to climate changes while others claim that the outbreak was due to feeding antiretroviral drugs to pigs for fattening purposes.

### **5.3.3 Trends of ASF cases in the study areas**

Within study districts, producers in Songwe (74%), Momba (71%) Songea (72%) and Mbinga (84%) reported that ASF outbreaks commenced at farm level in 2017. But still there is seasonal variation in the occurrence of ASF outbreaks whereby most outbreaks were reported in March - June (Songwe), June - September (Momba), November – January (Songea) and November – March (Mbinga).

### **5.3.4 Sources of disease information in the study areas**

The analysis showed that pig producers received information on ASF outbreaks from different sources. Different proportions of respondents in Songwe (54%), Momba (47%) Songea (50%) and Mbinga (75%) responded to receive information from their fellow farmers, followed by information from veterinary officers in Songwe (21%), Momba (10%) Songea (21%) and Mbinga (3 percent) (Fig. 5.2).



**Figure 5.2: Sources of disease information**

### 5.3.5 Producer behaviour during ASF outbreaks

It was found that different proportions of respondents in Songwe (26%), Momba (61%), Songea (46%) and Mbinga (50%) did nothing when outbreaks occurred. Some respondents in Songwe (38%), Momba (12%), Songea (42%) and Mbinga (20%) reported to call a livestock officer in case of an outbreak occurrence. Other few producers in Songwe (16%), Momba (10%), Songea (10%) and Mbinga (24%) reported to sale health pigs to avoid mortality in pig populations during ASF outbreak.

### 5.3.6 Risk factors associated with ASF outbreaks in the production node

A total number of 12 variables were included in univariate logistic regression analysis. The results of the univariate regression analysis indicate that four variables were significantly associated with the outcome variable at  $P \leq 0.20$  and these were included in multivariate analysis to produce a final model. Risk factors associated with ASF outbreaks in Songwe region were sharing of boars ( $P < 0.01$ , OR= 7.05 and CI<sub>95%</sub>=1.78; 28.00) and sharing of farm equipment ( $P < 0.04$ , OR= 4.14 and CI<sub>95%</sub>=1.07; 16.09) (Table 5.1).

**Table 5.1: Multivariate Logistic Regression analysis in Songwe region**

Variables	B	S.E.	Wald	df	Sig.	Exp (B)	95% C.I. for EXP(B)	
							Lower	Upper
Free ranging system	-1.82	0.93	3.79	1	0.05	0.16	0.03	1.01
Sharing boars	1.95	0.7	7.71	1	0.01	7.05	1.78	28
Improper waste disposal	-1.04	0.74	1.99	1	0.16	0.35	0.08	1.5
Sharing farm equipment	1.42	0.69	4.21	1	0.04	4.14	1.07	16.09
Constant	-2.46	1.02	5.81	1	0.02	0.09		

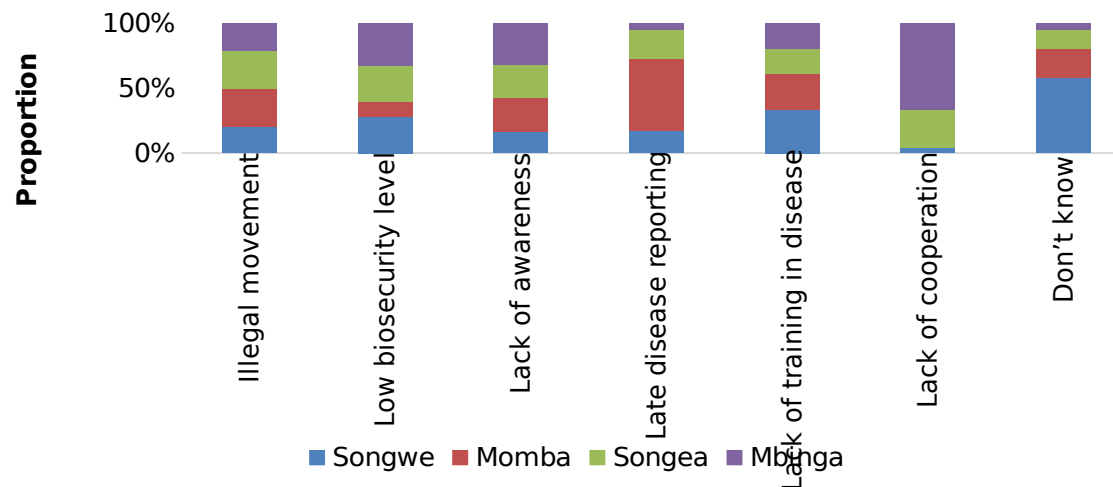
Similar analysis was performed for Ruvuma region whereby four variables had significant association with the outcome variable during univariate analysis and were included in multivariate analysis. Presence of warthog and/or bush pigs ( $P < 0.01$ , OR= 3.08 and CI<sub>95%</sub>=1.33; 7.14) and visitors access to farm ( $P < 0.01$ , OR= 2.38 and CI<sub>95%</sub>=1.23; 4.61) were positively correlated with ASF outbreak in the region (Table 5.2).

**Table 5.2: Multivariate Logistic Regression analysis in Ruvuma region**

Variables	B	S.E.	Wald	df	Sig.	Exp (B)	95% C.I. for EXP(B)	
							Lower	Upper
Introduction of new herd	0.47	0.32	2.14	1.00	0.14	1.61	0.85	3.03
Sharing boars	0.50	0.28	3.28	1.00	0.07	1.65	0.96	2.83
Presence of Warthog/bush pig	1.12	0.43	6.88	1.00	0.01	3.08	1.33	7.14
Visitor's access	0.87	0.34	6.58	1.00	0.01	2.38	1.23	4.61
Constant	-1.850	0.507	13.342	1	0.000	0.157		

### 5.3.7 Factors hindering ASF control in the study areas

There are a number of factors which hindered ASF control in the study areas. These include low biosecurity at farm level in Mbinga (30%) Songwe (25%) Momba (11%), Songea (25%) and lack of training on disease management in Songwe (26%), Momba (23), Songea (16%) and Mbinga (16%) as shown in Fig. 5.3.



**Figure 5.3: Factors hindering ASF control****5.4 Discussion**

In the present study, risk factors associated with occurrence of ASF outbreaks in Songwe and Ruvuma regions were assessed. The findings revealed that majority of producers lacked knowledge on ASF transmission pathways which result into circulation of ASFV within the study areas. This finding is in contrast with study which reported that lack of knowledge on ASF was not a cause for ASF virus circulation in Northern Uganda (Chenais *et al.*, 2017). The difference could be contributed by lack of animal health training and disease management programs in Songwe, Momba, Songea and Mbinga districts.

In all districts, many producers reported ASF cases in 2017. However, there were seasonal variations in outbreaks between study districts. In this study, outbreaks were reported during rainy season in Songwe, Songea and Mbinga districts. This finding could inform the outcome of rainy water flow in the transmission of ASFV from susceptible areas such as slaughter slabs to other areas. However, this explanation needs further research to provide evidence on ASF epidemiology. Moreover, like other livestock producers, during the rainy season pig producers are engaged more in crop production activities as a result they are careless about biosecurity measures such as routine cleaning of premises or boiling of leftovers and good livestock husbandry. Other ASF outbreaks occurred in dry season in Momba district. This observation supports a study in Nigeria in which authors found that there is higher ASF seropositivity during the dry season than in the

rainy season (Awosanya *et al.*, 2015). Similarly, the tendency of ASF outbreaks to occur in dry season has been reported in previous studies in Uganda. However, there were not clear explanations on the epidemiological pattern (Atuhaire *et al.*, 2013; Dione *et al.*, 2014).

In all the study districts, the source of disease information outbreak was disseminated between producers within proximity farm. Further, the findings revealed that there is relatively low rate of reporting disease outbreaks between pig producers and the local veterinary authority. Similar observation was reported in a study by Mokoetele *et al.* (2015) that assessed perceived risk of transboundary disease and the impact of provincial veterinary services in South Africa.

The findings of this study show that pig producers borrowed or shared boars for breeding within neighborhood farms. This practice has a positive association with ASF outbreaks especially when producers do not quarantine the boars for days before allowing contacts with their sows. Perhaps producers were sharing boars because they are few within districts which indicate that there is an opportunity for producers to invest in breeding and supply to other producers. In addition, sharing of farm equipment such as gumboots, shovels and rakes without disinfecting them was practiced by producers and was found to be positively correlated with ASF outbreaks. Similar risk factors for occurrence of ASF in Ruvuma region were also reported in studies conducted in Uganda (Kabuuka *et al.*, 2014; Dione *et al.*, 2017). These include presence of warthogs/bush pigs and farm visitors near pig premises. Geographically, Ruvuma region is bordered by Selous Game Reserve thus allows interaction between domestic pigs and wild animals such as warthogs/bush pigs. Direct observation revealed that many

pig premises have no fence around, this offers access to visitors such as traders and veterinary officers near pig premises without implementation of any biosecurity measures hence increase chances for spreading disease.

The control of ASF was limited by low level of biosecurity within farms as well as lack of training on disease management. Perhaps government sensitization on the benefit of implementation of biosecurity measures as reported in a previous study in Nigeria could reduce the number of ASF cases (Fasina *et al.*, 2012b). Moreover, regular veterinary services to strengthen capacity building on disease management could offer producers the opportunity to prevent diseases at farm level (Chenais *et al.*, 2017).

## **5.5 Conclusion**

The present study provides an insight on risk factors related to ASF outbreaks of which require active measures to intervene. Sharing of boars, sharing of equipment, presence of warthogs and farm visitors were associated with ASF outbreaks in Songwe and Ruvuma regions. Therefore, the intervention on increasing boar breeding supply, use of clean and disinfected equipment, limiting visitors near pig premises/building of fence and avoiding pig farming near reserved areas could provide feasible prevention, control and eradication of the ASF outbreaks in Songwe and Ruvuma regions of Tanzania.

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**CHAPTER SIX**

**Manuscript 3: Economic Implications of African Swine Fever Outbreaks of 2017/ 2018 in Songwe and Ruvuma Regions, Tanzania**

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**Abstract**

Determination of economic implications related to African Swine Fever (ASF) outbreak in endemic areas is essential in order to provide justification for disease management and control in Tanzania. The objective of this paper was to determine financial losses related to ASF outbreaks in 2017/2018 in Songwe and Ruvuma Regions of Southern highlands of Tanzania. It was a cross-sectional study that involved administration of questionnaires and face to face interviews to pig producers and traders in order to assess financial losses due to mortality in pig population and trade restriction. A total number of 484 producers and 23 retailer traders were interviewed. Ruvuma had higher proportion of pig producers (60%) compared to Songwe (35%). Approximately 12% and 31% of the respondents reported to sale pigs due to the ASF outbreak in 2017/2018 in Ruvuma and Songwe regions, respectively. Mortality rates were higher in adult sows 29% and piglets 31% population than growers and the implication was higher in Songwe than in Ruvuma. Study results revealed limited knowledge in animal health management in Ruvuma (89%) and Songwe (94%). The estimated direct losses on producers were 165 785 000 TZS and 119 615 883 TZS in Ruvuma and Songwe, respectively. The indirect losses on traders were 5 665 000 TZS in Songwe and 18 799 350 TZS in Ruvuma. The implication of ASF outbreak include reduction of productivity and supply of pigs. Strengthening veterinary training on routine disease surveillance for early detection and disease outbreak reporting may help to reduce disease burden in endemic areas hence reducing economic losses.

**Key words:** Disease, Financial losses, Pig production, Tanzania

**Targeted Journal:** Tropical Animal Health and Production.

## 6.1 Introduction

In Tanzania, approximately 190 000 households and 1 436 enterprises depend on pig sector for income generation and source of animal protein (Maziku *et al.*, 2017; URT, 2017). Overall, the livestock sector contributes 7.6 percent to the country Gross Domestic Product (GDP) (URT, 2019), whereas the pig sector accounted for about 3.7 percent of white meat products (Wilson and Swai, 2014). Despite the contribution of the pig industry to household and national economy, there are several constraints to the development of the sector. These include poor husbandry, poor feeding practices, lack of veterinary services and infectious diseases such as African Swine Fever (ASF) (Dione *et al.*, 2014; Karimuribo *et al.*, 2014).

African Swine Fever is a highly contagious hemorrhagic disease which affect domestic pigs. The disease is endemic in almost 22 African countries including Tanzania (FAO/ILRI/AU, 2017). In Tanzania, the disease was reported in 1962, 1987 and 1988 (Wambura *et al.*, 2006). After a decade absence, the disease resurfaced in 2000 (Misinzo *et al.*, 2014). The outbreaks of ASF have been frequently reported in different regions including Mbeya, Iringa, Dar es Salaam, Rukwa and Morogoro (Misinzo *et al.*, 2012). The disease is a major constraint in both traditional and commercial production systems (Karimuribo *et al.*, 2014; Wilson and Swai, 2014; Maziku *et al.*, 2017). The occurrence of outbreak causes direct and indirect losses to people's livelihoods and threaten food security (Costard *et al.*, 2009). Several initiatives have been made to prevent ASF through identifying risk mitigation and improving organization of pig value chain (FAO/ILRI/AU, 2017). Other details on the disease control measures are available in published reports (Fasina *et al.*, 2012; FAO 2009; Penrith *et al.*, 2009).

However, the prevention and control measures faced many challenges including absence of vaccine, epidemiological complex and complexity of value chain (Dione *et al.*, 2016; Misinzo *et al.*, 2014).

There are several studies that have documented the economic implications of the ASF. For instance, pig mortality losses were estimated up to 2.1 billion TZS (US\$ 941 491.67)<sup>1</sup> in an outbreak of 2001 in Ibadan, Nigeria (Babalobi *et al.*, 2007). In Ghana in 1999 approximately 200 000 pigs were slaughtered in order to control the disease (Kouakou *et al.*, 2017). The outbreak in Rombo, Tanzania in 2013 caused an estimated loss of 160. 632 million TZS (Swai and Lyimo, 2014).

Due to the economic implication of the animal diseases, an increasing effort has been made to apply animal health economic principles in making veterinary decisions. The presence of data on animal diseases is a necessity when deciding on policy intervention (Dijkhuizen *et al.*, 1992). Moreover, the economics of animal disease provide many advantages such as quantifying the financial implication of the disease, estimating the cost and benefit of disease control and decision making for intervention based on the affected population (Dijkhuizen *et al.*, 1995).

In recent years ASF has repeatedly occurred in Tanzania, but there is limited number of studies that focused on its economic implications at both household and national level. Therefore, the aim of this study was to determine financial losses that resulted from ASF outbreak in

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<sup>1</sup> 1 USD =2300 TZS

2017/2018 in Songwe and Ruvuma Regions. This information will help to generate more evidence on the economic implication of the disease hence provide justification for its management and control measures in Tanzania.

## **6.2 Materials and Methods**

### **6.2.1 Study area**

This study was conducted in Songwe Region (Songwe and Momba districts) and Ruvuma region (Songea and Mbinga districts). The selection of the regions was based on the previous episodes of outbreaks and high pig production in the areas. Both regions experienced ASF outbreaks between 2017 and 2018. Songwe region has approximately 79 513 pigs (URT, 2015) and Ruvuma region has a population of 116 689 pigs (URT, 2017).

### **6.2.2 Study designs and sampling procedures**

The study adopted a cross-sectional design which involved collection of data from pig producers and retailer traders. Twelve villages and seven streets affected by ASF outbreak in 2017/2018 were purposively sampled. In each village/street 25 households were randomly selected for interviews. Selected households consisted both those which were affected with ASF outbreak in 2017/2018 and those which were not affected. The sampling of pig traders depended on information from livestock field officers and traders themselves and as previously described by Mtimet and Baker (2013) in Uganda. Data were collected using questionnaires. Information sought included

experience in pig production, reason for selling pigs, availability of training, ASF experience, mortality in pigs, abortion due to ASF, buying and selling prices.

### 6.2.3 Data analysis

#### 6.2.3.1 Direct losses due ASF on pig producers

Data were entered in Microsoft Excel<sup>®</sup> and analysis was done using Statistical Package for Social Scientists (SPSS)<sup>®</sup> version 25 (IBM Corp, Armonk New York, USA). Bennett and Kitching (2000) spreadsheet model was adopted to determine direct losses due to mortality of pigs and abortion. Parameters used included mortality rate, prevalence of ASF, herd size, value of live animal, number of aborted fetuses and value of aborted fetuses. Therefore, direct losses were calculated by the following equations;

$$\text{Direct losses} = \text{Mortality} + \text{abortion} \dots\dots\dots (1)$$

$$\text{Mortality losses} = m_r \times P_r \times n_h \times L_a \dots\dots\dots (2)$$

$$\text{Abortion losses} = N_u \times V_u \dots\dots\dots (3)$$

Where;

$m_r$  = mortality rate (%)

$P_r$  = prevalence of ASF (%)

$n_h$  = number of herd size

$l_a$  = value of live animal

$N_u$  = number of aborted pig

$V_u$  = value of aborted pig (TZS)

The estimated values of live pigs were 50 000 TZS for a piglet, 120 000 TZS for a weaner grower, 200 000 TZS for a fatter/breeder, 400 000 TZS for an adult sow and 300 000 TZS for an adult boar (own survey, 2018). Mortality rate used was 100% (Ouma *et al.*, 2018) and 50% prevalence for unknown population in study areas. Lastly independent t test was used to compare economic implications of ASF between Songwe and Ruvuma regions.

### 6.2.3.2 Indirect losses due ASF on pig traders

In this study some assumptions were made in order to calculate indirect losses due to ASF on pig traders. The following were the key assumptions; the study assumed that traders could lose the same amount of profit due to trade restriction by government during outbreaks. Fixed costs such as costs for livestock tools/equipment and value of land were assumed constant due to the reason that these costs were not categorized as separate entity for the pig business. Therefore, profitability of pig traders was estimated using Gross margin (GM) analysis method. The Gross margin was calculated according to the formula equation four by Johnsen (2003).

$$GM = TR - TVC \dots\dots\dots (4)$$

Where;

GM = Gross margin (TZS/Unit)

TR = Total revenue (TZS/Unit)

TVC = Total valuable cost (TZS/Unit)

### **6.3 Results**

#### **6.3.1 Demographic characteristics of respondents**

In this study, pig producers from Songwe (n=196) and Ruvuma (n=288) were interviewed. The percentages of males and females were 55% and 45% respectively, and more than 70% lived with spouses. Majority of respondents (75%) attained primary education. In terms of household size, many had 6 – 10 people in Songwe while 1-5 people in Ruvuma. The respondents had minimum age of 13 and maximum age of 85. Other respondents were pig traders from Songwe (n=7) and Ruvuma (n=16). The respondents had minimum age of 17 years and maximum of 65 years. Majority of traders were males, married and had acquired primary education. The household size of traders was between 1-5 people.

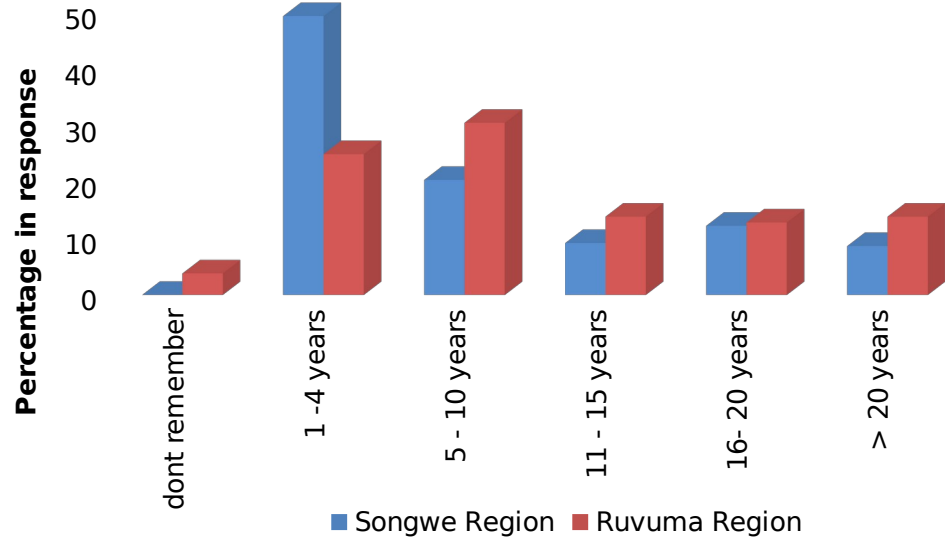
#### **6.3.2 Livestock production in the study areas**

Of the 484 pig producers, 48% reported pigs as their main livestock followed by local chicken (24%) and goats (12%). Ruvuma had higher proportion of pig producers (60%) compared to Songwe (35%) (Table 6.1). Majority of respondents had 1 to 10 years of experience in pig production.

Variables	Songwe Region			Ruvuma Region			Total (N=288)	Grand Total (N=484)
	Songwe (n=99)	Momba (n=97)	Total (N=196)	Songea (n=119)	Mbinga (n=169)	Total (N=288)		
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	
Pigs	34.7	35.1	34.9	47.7	73.5	60.3	47.6	
Local chicken	23.8	24.6	24.2	26.0	18.8	22.5	23.5	
Cattle	14.8	18.7	16.6	7.7	2.0	5.0	10.8	
Sheep	3.4	1.9	2.5	1.4	0.5	1.0	1.7	
Goat	14.9	14.5	14.7	15.5	2.8	9.4	12.0	
Duck	6.7	3.7	5.3	0.7	2.0	1.3	3.3	
Donkey	1	1.5	1.4	0.7	0.0	0.4	0.9	
Rabbit	0.7	0	0.4	0.3	0.3	0.3	0.3	

**Table 6.1: Types of livestock owned by producers in Songwe and Ruvuma regions**

In Songwe region, about 50% of the respondents reported to have between one to four years of experience in the production. While 31% of the respondents in Ruvuma had five to ten (10) years of experience in the sector. Very few people had more than 10 years of experience in pig production (Fig. 6.1).



**Figure 6.1: Years of experience in pig production**

### 6.3.3 Pig production as a source of livelihood

Pig production is regarded as a source of livelihood amongst the livestock keepers. The results show that pig producers in Songwe (10%) and Ruvuma (20%) reported to sale pigs for buying household food while 12% and 31% reported to sale pigs due to ASF outbreak in 2017/2018 in Ruvuma and Songwe regions, respectively. Other respondents in Ruvuma (40%) and Songwe (55%) were unable to sale pigs due to mortalities at the farm level (Fig. 6.2).



	<b>No. Mortality (% Mortality)</b>						
Piglets	396 (33)	291 (38)	687(35)	173(29)	64 (15)	237 (23)	924 (31)
Weaner	258(22)	148 (20)	406(21)	60(10)	83 (19)	143 (14)	549 (18.4)
Grower	162(14)	49 (6)	211(11)	50(8)	44 (10)	94 (9)	305 (10.2)
Fattener	24 (2)	30 (4)	54 (3)	0(0)	0 (0)	0 (0)	54 (1.8)
Adult sow	271(23)	182 (24)	453(23)	260(43)	154 (36)	414 (40)	867 (29)
Adult boar	88 (7)	57 (8)	145) (7)	58 (10)	81 (19)	139 (14)	284 (9.5)
<b>Total</b>	<b>1199 (100)</b>	<b>757(100)</b>	<b>1956(100)</b>	<b>601(100)</b>	<b>426 (100)</b>	<b>1027 (100)</b>	<b>2983 (100)</b>

### 6.3.5 Direct losses due to ASF among pig producers in Songwe and Ruvuma regions

The direct losses associated with 2017/2018 ASF outbreak were estimated at 285 400 883 TZS. The estimated loss in Songwe amounted to 165 785 000 TZS while in Ruvuma it was 119 615 883 TZS. Mortality accounted for the highest cost 276 500 883 TZS followed by abortion 8 900 000 TZS (Table 6.3). There was no statistically significant difference in the losses caused by ASF between the two regions ( $p=0.165$ ).

**Table 6.3: Financial losses associated with ASF outbreak in Songwe and Ruvuma region**

<b>Variables</b>	<b>N</b>	<b>Total losses</b>	<b>%</b>	<b>Range Maximum</b>	<b>Range Minimum</b>	<b>Mean</b>	<b>Standard Deviation</b>
<b>Songwe region</b>							
Losses due to mortalities	196	157 735 000.00	95.1	14 450 000.00	0.00	804 770.41	1 310 047.35
Losses due to abortion	196	8 050 000.00	4.9	1 750 000.00	0.00	41 071.43	150 710.48
Total losses	196	165 785 000.00	100	16 200 000.00	0.00	845 841.84	1 460 757.83
<b>Ruvuma region</b>							
Losses due to mortality	288	118 765 883.00	99.3	9 125 000.00	0.00	412 381.54	843 611.80
Losses due to abortion	288	850 000.00	0.7	200 000.00	0.00	2 951.30	17 178.73
Total losses	288	119 615 883.00	100.0	9 325 000.00	0.00	415 332.84	860 790.53
Grand losses	484	285 400 883.00		25 525 000.00	0	1 261 174.68	2 321 548.36

### 6.3.6 Indirect losses due to ASF among the pig traders

The results of the study revealed that, retailers lost approximately 24 464 350 TZS during the 2017/2018 ASF outbreak. Ruvuma was the most affected region, with a total loss of 18 799 350 TZS compared to Songwe region where the loss amounted to 5 665 000 TZS (Table 6.4).

**Table 6.4: Profit margin at retailer node per month in Songwe and Ruvuma regions**

Revenue variables	Songwe Region			Ruvuma region		
	Songwe (n=5)	Momba (n=2)	Total (n= 7)	Songea (n=11)	Mbinga (n=5)	Total (n= 16)
Quantity sold /Kg	1 920	600	2520	4 950	3 750	8 700
Selling price/ kg	5 000	5 000	5 000	6 000	6 000	6 000
<b>Total revenue</b>	<b>9 600 000</b>	<b>3 000 000</b>	<b>12 600 000</b>	<b>29 700 000</b>	<b>22 500 000</b>	<b>52 200 000</b>
Cost of live animal	4 480 400	1 400 700	5 880 000	16 500 200	11 250 000	27 750 200
Building rent	202 500	56 000	258 500	830 000	1 200 600	2 030 600
<b>Variable cost</b>						
Firewood	116 000	26 000	142 600	1 025 800	295 000	1 320 200
License	12 000	-	12 000	200 000	100 000	300 000
Salary	48 000	79 000	125 000	811 900	375 000	1 186 900
Village fees	41 000	12 000	53 000	-	-	-
Oil cost	66 000	176 000	242 000	-	-	-
Sanitary fee	6 900	14 000	20 000	1000	17 000	18 000
Security	-	-	-	120 000	30 000	150 000
Water	92 100	110 400	202 500	60 750	30 000	90 750
Electricity	-	-	-	41 000	30 000	71 000
Other cost	-	-	-	279 000	204 000	483 000
<b>Total cost</b>	<b>5 064 600</b>	<b>1 870 400</b>	<b>6 935 000</b>	<b>19 869 650</b>	<b>13 531 600</b>	<b>33 400 650</b>
<b>Gross margin</b>	<b>4 535 400</b>	<b>1 129 600</b>	<b>5 665 000</b>	<b>9 830 350</b>	<b>8 960 400</b>	<b>18 799 350</b>

### 6.3.7 Livestock management practices and disease control

The findings of the study revealed that over 95% of producers in Ruvuma practice confinement production system while 56% of the producers practice semi confinement production system in Songwe. In both regions, pig producers reported to use traditional

feed such as maize bran, green leaves, brew residual and leftovers to feed pigs. There is poor management of waste products whereby, majority used to throw away or feed waste to pigs. Moreover, the level of skills in animal health management was assessed and found to be inadequate. Many producers in Ruvuma (89%) and Songwe (94%) lacked training services on disease management, and skills on biosecurity measures to improve productivity.

#### **6.4 Discussion**

As it is the case in other African countries pig industry has a significant contribution on income generation and source of protein to many people especially in rural areas of Tanzania (Karimuribo *et al.*, 2014; Swai and Lymo, 2014; Wilson and Swai, 2014; Kimbi *et al.*, 2015; 2016). However, ASF is the number one killer of pigs with a huge effect on people's livelihoods and trade restriction (Maziku *et al.*, 2017).

In Ruvuma region, majority of producers have an experience of more than five years compared to producers in Songwe region with an experience of less than five years. Experience of one to four years in pig production activities in Songwe region could imply that this is an evolving activity. A similar observation was reported in a study in Ethiopia (Mekuriaw and Asmare, 2014). However, fewer years of experience in keeping pigs could demonstrate that producers are still naïve in animal disease management while more experience in production implies that there is an opportunity for pig producers to combat against production constraints including disease management.

Since ASF outbreak causes mortality in pig population up to 100%, pig producers in Songwe (31%) and Ruvuma (12%) reported to sale their pigs during outbreaks. These results are in agreement with Dione *et al.* (2016) who reported on panic sale in

community to avoid financial losses. Other producers in Songwe (55%) and Ruvuma (40%) lost pigs before making an attempt to sale during outbreak. This means that there is a decrease in household income to cover domestic need such as food, school fees, medical or other investment.

The mortality rate was high in adult sows (29%) and piglets (31%) as compared to growers. Due to this mortality, pig producers are more likely to shift to other livestock animals leading to less sustainability in the pig industry. Similar observation was documented in the analysis of ASF outbreak in 2001 in Nigeria (Babalobi *et al.*, 2007).

The financial losses of approximately 165 785 000 TZS and 119 615 883 TZS at farm level in Songwe and Ruvuma regions respectively show that ASF can disrupt pig industry and people who depend on the sector. The outbreak disrupted both regions in the same way as it was found that there is no statistically significant difference in the mean financial losses between regions. However, there is no government compensation or livestock insurance scheme available to cover for the losses due to disease outbreaks (FAO/ILRI/AU, 2017). Besides these huge losses, pig producers lack continuing training on animal health and good husbandry practices. Perhaps improved veterinary training on routine surveillance for early detection, disease reporting and good husbandry could reduce mortality in pig population. Parallel to this adequate training on disease risk and clinical manifestation should be provided to livestock field officers, livestock keepers and other stakeholders in endemic areas (Sánchez-Vizcaíno, 2009).

On the marketing side, traders were also affected with indirect losses due to trade ban. This happened when government authorities restricted marketing and pig movements within affected areas as measure to control the disease. In addition, due to the

transboundary nature of the disease, trade restriction could go beyond local to regional and international trade. In this study, it was found that if the government restricts trade for one month in affected study areas, the financial losses on retailer traders could reach up to 5 665 000 TZS and 18 799 350 TZS million per industry in Songwe and Ruvuma regions respectively. The difference in estimated losses was caused by on and off marketing activities in Songwe region compared to Ruvuma region.

From the findings of this study, it was revealed that ASF outbreak increases direct losses to pig producers especially those who do not implement biosecurity measures. Therefore, the following are recommendations; i) sensitization on implementation of biosecurity measures at farm levels; ii) formation of farmers and traders organizations to improve pig value chain structure and organization; iii) promoting disease surveillance and training on disease transmissions pathways; iv) improving marketing infrastructures such as modern slaughter slab are likely to be important to engage traders in reducing the risks of ASF transmissions and v) promoting animal health research in collaboration with other regional and international organizations to develop vaccine that can prevent ASF.

Among the limitations that this cross-sectional study faced was inability to account for biological causes and effects of abortion and mortality in pig population. Reliance on information obtained from producers whose adult sows had an abortion or sudden death without laboratory confirmation of aborted fetuses or blood from affected pigs could likely cause biased in data collected because other pig diseases could also cause abortion or death in pigs. However, care was taken based on clinical manifestations of ASF disease when identifying affected households.

## **6.5 Conclusion**

The economic implications of ASF outbreak include a reduction in the productive, supply of pigs and food in-security. The estimated financial losses on people's livelihoods and impact on food security caused by the disease entail the rationale for prevention and control of ASF in Tanzania. Therefore, capacity strengthening of veterinary training on routine surveillance, and early disease reporting at farm level may help to reduce disease burden. This could be achieved through education intervention on identification of disease risk and clinical manifestation to producers, field officers and other stakeholders in endemic areas.

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## **Conflict of interest**

None.

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## **CHAPTER SEVEN**

### **7.0 CONCLUSION AND RECOMMENDATIONS**

#### **7.1 Summary**

This study was conducted to determine risk factors and economic implications of ASF disease in Songwe and Ruvuma regions of Tanzania. To achieve this objective value chain approach was used to assess chain operations and activities at different nodes and determine the risk practices that are related to ASF occurrence within the pig value chain. Financial losses associated with ASF on actors within the chain were also estimated in order to provide justification for disease prevention and control in Tanzania. Primary data were collected using structured questionnaires, semi structured key informant interviews and observation method. A total number of 484 pig producers and 28 traders were interviewed. Data were analyzed in Statistical Package for Social Sciences (SPSS) version 25 in which descriptive statistics were computed and logistic regression performed. Spreadsheet model and Gross Margin were used to determine financial losses associated with ASF.

#### **7.2 Conclusion**

Regarding the first objective of the study, the assessment of pig value chain in Songwe and Ruvuma Regions described main four nodes which are production node, transportation node, slaughter slab node and marketing node. In general, all nodes performed under poor biosecurity measures, poor infrastructures and facilities which could contribute to introduction and spread of ASF. Furthermore, the transportation node carried out high disease risk due to many pick-ups and movements during night followed by marketing nodes.

In the second objective, logistic regression was used to determine risk factors that related to ASF occurrence within pig value chain. Sharing boars and sharing equipment were found to be risk factors associated with ASF outbreak in Songwe Region, while presence of warthogs/ bush pigs and farm visitors were risk factors in Ruvuma region. Therefore, the opportunity for ASF control exist in investing in breeding supply, the use of disinfectants, restricting animal keeping near reserved areas and building of fences near pig premises.

In the analysis of the third objective, the finding revealed that there are huge losses of up to 165 785 000 TZS and 119 615 883 TZS at farm level in Songwe and Ruvuma Regions respectively. The null hypothesis was rejected since there was no statistically significant difference between mean financial losses in Songwe and Ruvuma regions. This implies that both regions were affected equally. Moreover, an assumption was made to calculate indirect losses due to ASF on traders. Whereby, it was assumed that traders could lose the same amount of profit due to trade restriction by government during outbreaks. The indirect losses were estimated up to 18 799 350 TZS and 5 665 000 TZS at marketing level in Ruvuma and Songwe Regions respectively. These findings provide evidence that the economic implications of ASF outbreak could lead to huge reduction in the production and supply of pigs and food security.

### **7.3 Recommendations**

Based on assessment of the pig value chain, the study revealed that there is high risk of introduction and spreading of ASF at all nodes as well as huge financial losses therefore, the following are recommended;

### **7.3.1 Recommendations to Pig producers**

- i. Need for pig producers to avoid risk practices that are related to ASF outbreaks.
- ii. Need for formation of pig producers' cooperative societies along pig value chain to improve operations and ensure access to market information.
- iii. Improving close communications/networking with extension officers for various training in order to ensure animal health management and disease control.

### **7.3.2 Recommendations to Pig traders**

- i. Need for pig traders to formally registered their business and follows rules and regulations within pig value chains.
- ii. Improving biosecurity measures during transportation of animals and products from area to another.
- iii. Improving marketing infrastructures with modern slaughter slab in order to reduce the risks of ASF transmissions.

### **7.3.3 Recommendations to Policy Makers/Government Authorities**

- i. Improved livestock extension services geared towards sensitization of pig value chain actors on application of biosecurity measures at farm level and marketing channels.
- ii. There is need to enforce application of livestock policy such as animal movement control.
- iii. The need for capacity strengthening of veterinary services on surveillance, and early disease reporting at farm levels.

- iv. Need for promoting animal health research development in collaboration with other regional and international organizations.

#### **7.4 Areas for Further Research**

This study was purposefully aimed to assess pig value chain in affected areas, further research should be done to assess pig value chain in unaffected areas in order to provide an understanding of disease management strategies in endemic areas. Also, epidemiology of disease during the rainy season needs further investigation.

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## APPENDICES

### **Appendix 1: Risk factors and Economic implications of African Swine Fever in pig value chain in Songwe and Ruvuma regions, Tanzania**

#### **Oral informed consent form for respondents: Consent form to be signed by moderator**

##### **Instructions**

1. Read and review the Oral Consent Form with participants.
2. Ask the following: Are you willing to be in this survey to talk about pig production, pig marketing, risk factors associated with ASF outbreak and economic implications of disease? If one is willing; proceed to (3) below
3. Read the oral consent for them before the session begins. NOTE: If the participant is unwilling, stop the procedure Introduction.

“Good Morning/Afternoon”. My name is ..... from Sokoine University of Agriculture. I would like to invite you to join the study so that we can gather information on pig production and marketing, risk factors associated with occurrence of ASF and economic implications of disease to farmer and traders within your area. During the questionnaire survey, among the activities that will take place are interviews with livestock officers, livestock field officer, pig farmers and pig traders. Any farmers, or traders living in this area for the past one year can participate. The exercise will last for 30 minutes and the answers I get from you and several others will be analyzed to get the general populations knowledge and opinions concerning the pig production, marketing and information on transmission and spread of ASF. You may ask the researchers any questions you have at any time. I would like to assure you that the information provided will be used for the intended purpose only and your identity will never be disclosed when

such information is presented. To avoid recording your names I will instead give each person a number which will be used to record what one says.

I will ask for some personal information, like your age, number of years of school you finished, number of children you have. I will write this information under the number codes you will be given. Your name will not be used in any reports. I am not able to pay you for participation. Participation into the study is voluntary.

If you have any questions regarding this research, you may contact Ms. Ntuli Ngosomwile, Morogoro; Tel: +255 788 129 142 or +255 712 163164

Respondent: I have read the consent form and understood the contents and procedures involved into the study. I fully agree to take part into the study.

Respondent's Signature: \_\_\_\_\_ Date: \_\_\_\_\_ Time: \_\_\_\_\_

## Appendix 2: Questionnaire for pig producers

### Background information

Code of respondent: \_\_\_\_\_

Ethnic group: \_\_\_\_\_

Village: \_\_\_\_\_

Ward: \_\_\_\_\_

District: \_\_\_\_\_

Region: \_\_\_\_\_

### Section A: Farmers Characteristics

1. Age and sex of respondent Age: \_\_\_\_\_ years

2. Sex of respondent male ( ) female ( )

3. Marital Status of respondent:

1= Single ( ), 2= Married ( ), 3= Divorced ( ), 4= Widowed ( ), 5= Others (Specify)

4. What is the highest level of education obtained?

1= Illiterate ( ), 2= Informal ( ), 3 = Primary ( ), 4 = Secondary ( ),, 5 = Tertiary( )

5. Household members: Total \_\_\_\_\_

5b. Household composition

Age category	0-14	15-24	25-54	55-64	65
response					

6 What is your primary occupation?

1= pig keeping/producers ( ), 2= Assembly ( ), 3= wholesalers ( ), 4= retailers( ) 5=

input suppliers ( ), 6=Wage employment ( ) 7= Others (Specify)

**Section B: Pig Production Management**

7. When did you start the pig farming? \_\_\_\_\_ (Year)

8. What are three main reason for keeping pigs? Please tick below

1= *Income generation* ( ) 2= *for reproduction* ( ) 3=*Manure production* ( )

4=*Domestic meat consumption* ( ) 5= *Cultural (dowry)* ( ) 6= *others specify*

\_\_\_\_\_

8b. Please rank the reason listed below L= (low) M= (medium) H= (high)

No	Reasons	Response
1.	Income generation	
2.	For reproduction	
3	Manure production	
4	Domestic meat consumption	
5	Cultural (dowry)	
6	Others	

9. What was the source of initial capital for starting pig farming?

1= *Own Saving* ( ), 2= *Family* ( ), 3= *Formal credit* ( ), 4= *Informal Credit* ( )

5= *others (Specify)*

10. What is the source of stock?

1. = *NGOs* ( ), 2 = *primary market* ( ), 3 = *neighbor farm* ( ), 4=*input suppliers* ( )

5= *gift from development project* ( ) 6= *others specify* \_\_\_\_\_

11. How many herd sizes do you have? Indicate your current herd size.

1= 1- 4 ( ), 2= 5 - 9 ( ), 3 = 10-14 ( ), 4 = 15-19 ( ), 5 = < 20 ( )

12. Do you own the land? 1= *yes* ( ), 2= *No* ( )

12b. If yes to 12a what total area of land do you own?

1= 1.00 - 2.00 acres ( ), 2= >2.00-4.00 acres ( ) 3= 4.00-10.0 acres ( ) 4= >10.0 acres ( )

13. Are you the owner of the (pig)? 1=Yes ( ) 2=No ( )

14a. If No to 13 who is the owner of the pig

1= Husband ( ), 2= Wife ( ), 3= Child ( ), 4= both 1and2 ( ), 5= All 1, 2 and 3 ( ), 6= relatives ( )

14b. Who take care of the pigs?

1= Husband ( ), 2= Wife ( ), 3= Child ( ), 4= both 1and2 ( ), 5= All 1, 2 and 3 ( ), 6= Hired labour ( ), 7= Others (Specify) \_\_\_\_\_

15. What type of production system do you practice?

1= confinement ( ), 2= Semi- confinement ( ), 3= Free range ( ), 4= tethering ( ) 5= Others (Specify) \_\_\_\_\_

16. Which type of pig breed do you keep?

1 = Local breed ( ), 2 = Exotic/Pure breed ( ), 3= Cross breed ( )

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

1= Maize bran ( ), 2= hotel leftovers ( ), 3= Kitchen leftovers ( ), 4= Rice bran ( ), 5= Grass ( ), 6= blood meal ( ), 7= bone meal ( ), 8=green leave or vegetable ( ) 9= table salt ( ) 10 = Sun flower seed cake ( ), 11= others specify\_\_\_\_\_

18. What types of materials have been used in the construction of pig pen?

Structure	Type of Materials
Roofing	a. Iron sheet ( ) b. Grass thatched ( ), c. No roof ( ) d. polythene sheet ( ) e. cement bags ( ), f. asbestos ( )
Walls	a. Wood ( ) b. burnt bricks ( ), c. poles ( ) d. blocks
Floor	a. Timber ( ) b. cement ( ) c. Earth floor/soil ( )

19. What mechanism do you use to keep record? 1= *Paper* ( ), 2 = *electronically* ( )

3= *don't keep record*

20. If no to 19 what could be the reason?

1=*cannot read and write* ( ), 2= *judged as less important* ( ), 3=*consume time* ( ),

4=*not used* ( ) 5=*other specify*

21. Please indicate other livestock type(s) you keep in the table below

Type of Livestock	Livestock kept (multiple )
1= <i>no local chicken</i> , 2= <i>cattle</i> , 3= <i>sheep</i> , 4= <i>goats</i> 5= <i>donkey</i> 6= <i>rabbits</i> 7= <i>local chicken</i> , 8= <i>ducks</i>	

### Section C: Production Costs at Farm level

22. Please indicate purchasing cost in 2017

Inputs	Quantity	Costs	Total cost
Piglets			
Weaners			
Growers			
Adult sow			
Fatteners			
Adult sow			
Feeding costs			
Others specify			

23. Please indicate labour cost in 2017

<b>Activity</b>	<b>Family labour</b> <i>1= daily, 2= Weekly 3= Monthly, 4= others</i>	<b>Hired labour</b> <i>1= Rarely, 2= Frequently, 3= Never</i>	<b>If hired labour at what costs</b>
Pigpen Cleaning activities			
Feeding activities			
Marketing activities			

24. Please indicate the type of diseases, cost and number of pigs treated in 2017

Have you received veterinary services?	1= Yes ( ) 2 = No ( )
Which treatment did you treat /vaccinate your pigs?	1=iron injection, 2= African swine flue 3= de worming 4= teeth trimming, 5= Other specify
What was the cost of the service per animal?	
How many animals did you treat?	

#### Section D: Marketing Information In 2017

25	How many live animals did you sell	
26	What is average equivalent animal weight (kg)	1= 7-10 2= >10 -20 3=>20 -30 4 =>30- 40 5= >40 -50

		6= <i>Other specify</i>
27	Selling price	1 = 100,000 - 200,000 TZS 2 = >300,000 - 400,000TZS 3 = >500,000TZS 4 = <i>Other specify</i>
28	What is the reason for selling pig?	1= <i>for domestic needs</i> 2= <i>for school fees</i> 3 = <i>agricultural investment</i> 4= <i>for building house</i> 5= <i>ASF outbreak</i> 6 = <i>specify</i>
29	Where do you sell your pigs	1= <i>At home</i> 2= <i>In the market</i> 3= <i>outside region</i> 4= <i>outside borders</i> 5= <i>other villages</i> 6= <i>Others (specify)</i>
30	Which means do you use to transport your animal(s)?	1= <i>Bicycle</i> , 2 = <i>Hired vehicle</i> , 3 = <i>Own vehicle</i> , 4= <i>Head carrying</i> , 5= <i>Motorcycle</i> , 6= <i>trekking</i> 7= <i>Others (specify)</i>
31	How long does it take to reach at the market? hours	1= <i>10-20mins</i> , 2= <i>30 - 45mins</i> 3= <i>1hrs</i> 4 = <i>&lt;2hrs</i>
32	Do you already have the buyer?	1= <i>Yes ( )</i> 2 = <i>No ( )</i>
33	Who bought the animal?	1= <i>Assemblers</i> 2 = <i>Wholesalers</i> , 3= <i>Retailers</i> 4= <i>Fellow farmer/neighbor</i>
34	Where do you make the transactions?	1= <i>Inside the village</i> 2= <i>other village</i> 3= <i>within region</i> 4= <i>neighbor region</i>
35	Do you use middlemen to sell your	1= <i>Yes ( )</i> 2 = <i>No ( )</i>

	pigs?	
36	What is the means of payment?	<i>1= Cash 2 = Paid later, 3= Advance payment</i>
37	Do you slaughter animals	<i>1= Yes ( ) 2 = No ( )</i>
38	If YES to 36 Where do you slaughter animals	<i>1= at home 2= Private slaughter slab 3 government slab 4 = no slaughtered animal, 5= others(specify)</i>
39	Do animals inspected each time before slaughtered?	<i>1= Yes ( ) 2 = No ( )</i>
40	If yes to 38 what is the cost of inspection?	<i>1=Never paid 2= 1,000 TZS , 3=&gt;1000-5000TZS 4 =&gt;5000TZS</i>
41.	What is the slaughter value of health animal?	<i>1=100,000 2=150,000 3 =300,000</i>
42	What is the price of meat? Per kilo	<i>1=2000 - 4000, 2 = 5000 - 7000 3=&gt;7000</i>
43	Who bought the meat?	<i>1= neighbor 2= butchers 3. Roast meat shops 4=consumers 5= others(specify)</i>

### Section E: Production and Marketing Constraints

44. What challenges did you face in the last 12 months in pig production and marketing?

Please give your ratings 1 (low) to 5 (high) for the questions below:

Na	Challenges	Rank
1.	Lack of knowledge about pig production	
2	Lack of capital to expand business	
3	Lack of access to inputs	
4	Lack of exotic breeding stock	
5	Unreliable market	
6	Theft of animals	
7	Diseases and pests	
8	Lack of livestock extension staff	
9	Un-availability of Pig vaccines and reliable medication	
10	High price of inputs	
11	Price uncertainty	
12	Lack of credit facilities	
13	Poor measurements system	
14	Lack of modern slaughter facilities	
15	Conflict with neighbours	

### Section F: Membership In Farmers Organization

45. Have you joined any farmer organization dealing with agriculture/ livestock?

1= Yes ( ), 2 = No ( )

46. If YES, what is the name of the organization? \_\_\_\_\_

47. When did you joined the organization \_\_\_\_\_ (Year)

48. If no to 47 please give reason?

1= Lack of information ( ), 2=too cost ( ), 3= no interest ( ), 4=not available within village ( ) 5=not well organized ( ), 6= only few benefits ( )

49. What services do you get from the organization?

1= for sell products ( ) 2= training and veterinary services ( ) 3= Provision of loan ( ) 4 =Input supply ( ) 5 other specify \_\_\_\_\_

50. What are benefits of joining farmer organization?

1= Market information, 2=loan accessibility 3= training session 4= low price of inputs 5=profitability 6. Advisory service 7= other specify

### Section G: Disease Information

51. How long have you been in the pig farming? \_\_\_\_\_ (Year)

52. Do you know African swine fever disease? 1= Yes ( ) 2 = No ( )

53. Do you have other names for African swine fever? Please mention \_\_\_\_\_

54. If yes to 53 what are the source of disease information?

1= TV ( ), 2 =radio ( ), 3= newspaper ( ), 4= mobile phone ( ), 5= veterinary officer ( ) 6= animal markets ( ), 7=fellow farmer ( ), 8= friend ( ), 9 = others (specify)

55. Have you experience ASF outbreak in your farm 2017? 1= Yes ( ) 2 = No ( )

56. If YES to 55 what clinical manifestations did you see?

1=fever ( ) 2= loss of appetite ( ), 3= shade seeking ( ), 4= clouding together ( ), 5= weakness of hind legs ( ), 6= reddening of mucous membrane ( ) 7= vomiting ( ), 8=diarrhea ( ) 9= abortion in pregnancy ( ), 10 = lameness( )

57. Have your neighbor encountered African swine fever at the same time?

1= Yes ( ) 2 = No ( )

### G2: Disease Morbidity

58. When was the outbreak started? \_\_\_\_\_ (Month and Year)

59. When was the outbreak stopped? \_\_\_\_\_ (Month and Year)

60. How many pigs did you have before outbreak?

Piglets	Weaners	Growers	Fatteners	Adult sow	Adult boar
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61. How many pig got sick?

Piglets	Weaners	Growers	Fatteners	Adult sow	Adult boar

62. How many did you recovered?

Piglets	Weaners	Growers	Fatteners	Adult sow	Adult boar

**G3: Disease Mortality**

63. How many animals died?

Piglets	Weaners	Growers	Fatteners	Adult sow	Adult boar

64. How many adult sows had abortions? \_\_\_\_\_

65. What was total expenditure on ASF control? \_\_\_\_\_ (TZS)

66. Before outbreak what was the price of live animals? \_\_\_\_\_ (TZS)

67. Before outbreak what was the price of meat? \_\_\_\_\_ (TZS)

68. How many live animals did you sell during outbreak?

Piglets	Weaners	Growers	Fatteners	Adult sow	Adult boar

69. During outbreak what was the price of live animals? \_\_\_\_\_ (TZS)

70. During outbreak what was the price of meat? \_\_\_\_\_ (TZS)

71. How many did you sell during outbreak? \_\_\_\_\_

72. During outbreak did the government restrict trading of pigs 1= Yes ( ), 2 = No ( )

73 Did you stop keeping pigs? 1= Yes ( ), 2 = No ( )

74: If yes to 73 how long quite keeping pigs?

1=1-2 month ( ), 2 = 3 – 4 months ( ) 3 =>6 ( ) 4=other specify

#### G4: Disease Risk

75. Please respond to the following risk practice related to ASF outbreak

Risk factors	Response
How do you disposal waste product?	1= improper (throwing away, feed to pig promptly disposed of dead pigs 2=proper ( collection of waste, deep burial, burning, treatment)
Do you boil or treat waste product before feeding to pig?	1 =Yes ( ) 0 =No ( )
Do you treat swills to pigs?	1= Yes ( ) 0 = No ( )
Did you introduce any pigs into the herd before disease outbreak?	1 = Yes ( ) 0 =No ( )
Do you share a boar for breeding?	1 = Yes ( ) 0 =No ( )
Do you share farm equipment?	1 = Yes ( ) 0 =No ( )
Which equipment do you share	1=axe, 2= gumboots, 3= knife 4=rakes and shovels 5=hoes, 6= other specify
Are you feeding kitchen leftover?	1 = Yes ( ) 0 =No ( )
Are there any warthog /bush pigs around?	1 = Yes ( ) 0 =No ( )
Are there any ticks observed on pigs or premises?	1 = Yes ( ) 0 =No ( )
Have you received any training	1 = Yes ( ) 0 =No ( )
Do you wash and disinfect equipment and materials before use	1 = Yes ( ) 0 =No ( )
If Yes what kind of training did you receive	1=Improve productivity, 2=animal husbandry practices 3=biosecurity in pig farming 4= animal diseases management
Do livestock officer inspect animals before slaughter	1 = Yes ( ) 0 =No ( )
During outbreak which of the following action do you take	1= no action 2= call village vet 3= selling only health animal 4=selling both sick and health animals 5= selling only sick animal 6= buying sick/infected animals

#### G6: Diseases Mitigation

76. What measures did you adopt to control the disease?

1= quarantine ( ), 2= slaughter of animal ( ), 3=no action ( ), 4= stop doing pig business ( ), 5= quickly selling of pig ( ) 6=others specify

77. Please mention factors that hinders the mitigation of ASF

1= illegal livestock movement ( ), 2= low biosecurity level ( ), 3 = lack of awareness ( ) 4=late reporting of disease ( ), 5= lack of training on animal disease management, ( ) 6=lack of cooperation ( ) 7.Other specify

**THANK YOU FOR YOUR COOPERATION**

### Appendix 3: Questionnaire for pig traders

#### Background information

Name of respondent: \_\_\_\_\_

Ethnic group: \_\_\_\_\_

Village: \_\_\_\_\_

Ward: \_\_\_\_\_

District: \_\_\_\_\_

Region: \_\_\_\_\_

#### Section A: Traders Characteristics

1 Age and sex of respondent Age: \_\_\_\_\_ years

2. Sex of respondent male ( ) female ( )

3. Marital Status of respondent:

1= Single ( ), 2= Married ( ), 3= Divorced ( ), 4= Widowed ( ), 5= Others (Specify)

4. What is the highest level of education obtained?

1= Illiterate ( ), 2= Informal ( ), 3 = Primary ( ), 4 = Secondary ( ), 5 = Tertiary ( )

5. Household members: Total \_\_\_\_\_

5b. Household composition

Age category	0-14	15-24	25-54	55-64	65
response					

6. What is your occupation?

1= pig keeping/farmers ( ), 2= Assembly ( ), 3= wholesalers ( ), 4= retailers ( ), 5= input suppliers ( ), 6=Wage employment ( ), 7= others (Specify) \_\_\_\_\_

7. Do you have a business premise? 1= Yes ( ), 2 = No ( )

8. What was your initial investment cost?

1= 50000 - 200,000 TZS ( ), 2 = 250,000 - 500,000 TZS ( ) 3=>500,000 – 1,000,000TZS ( )

A. What is the form of the business ownership?

1= Sole proprietorship ( ), 2= Partnership ( ) 3= others (Specify)

10. Do you have licenses? = Yes ( ), 2 = No ( )

## **Section B: Purchasing and Selling Live Animals/Meat**

### **Wholesale and Retailer Informarion**

11. What are the reasons for purchasing animals?

1= Fattening animals ( ), 2= for breeding ( ), 3 = selling raw meat ( ), 4= roast meat ( )  
5=live animal ( ), 6=others (specify) \_\_\_\_\_

12. Where do you obtain your stock?

1= famers search for trader ( ) 2= go direct to farmer ( ) 3= own farm ( ) 4 = assemblers ( ) 5=wholesalers ( ) 6= market auction ( ) 7= service provider ( ) 8= others specify \_\_\_\_\_

13. If farmers comes to you, how many farmers do you purchase animals?

1= 1 ( ) 2 = 3-5( ), 3 = >5 ( ) 4 = others specified \_\_\_\_\_

14. If you go to farmers how often do you visiting pig farmers

1= Daily ( ), 2= Weekly ( ), 3= Monthly ( ) 4 = Quarterly ( )

15. Do you normally entered the pig premises 1=Yes ( ), 2 =No ( )

16. Do you apply biosecurity measure to avoid diseases risk such as ASF? 1 =Yes, 2 =No

17. If yes to 16 which of the following measures do you apply?

1= disinfection of boots ( ), 2= disinfection of vehicles ( ), 3= wearing special clothes ( )  
4=masks and gloves ( ), 5= well packaging of inputs ( ), 6= no measures ( )  
7=others

18. If from market auction, are animals for sale inspected?? 1= Yes ( ), 2 = No ( )

19. Do you grounded animals together before transaction? 1= Yes ( ), 2 = No ( )

20. What is the frequency of the market?

1=Daily 2= Weekly 3= Monthly 4= specify (other) \_\_\_\_\_

21. Which period has high season trade?

1= January – March ( ), 2= April –June ( ), 3=July –September ( ), 4=October – December

21b.Which period has low season trade?

1= January – March ( ), 2= April –June ( ), 3=July –September ( ), 4=October – December

22. Do sellers pay a commission at the market? 1= Yes ( ) 2 = No ( )

23. If YES how much do you pay per animal? \_\_\_\_\_

1. Never paid ( ) 2. 1,000TZS ( ), 3. >1000-5000 4. Other specify

24a. Who sells at the market?

1 = producers 2 = middlemen 3 = wholesalers 4 = others (specify) \_\_\_\_\_

24b. Who buys at the markets?

1 = producers ( ) 2 = wholesaler ( ) 3 = pig collectors ( ) 4 = retailers ( ) 5 = consumers ( )

25. What determine the quality of pig to purchase?

1 = by looking on fatness ( ) 2 = weight of animal ( ), 3 = good health of animal ( )  
4 other specify \_\_\_\_\_

26. What determine the buying price?

1 = famers ( ) 2 = market price ( ) 3 = bargaining power ( ) 4 = others specify

\_\_\_\_\_

27. Which means of transport do you use to transport animals?

1 = Trekked ( ), 2 = Bicycle ( ), 3 = Public transport ( ), 4 = Own vehicle ( ), 5 =  
Hired vehicle ( ), 6 = Head carrying ( ), 6 = others (specify)

28. How many animals do you carry per trip? \_\_\_\_\_

29. What type of products do you sell?

1 = live animal ( ) 2 = raw meat ( ) 3 = roast pork ( ) 4 = others specify \_\_\_\_\_

30. If it is live animal do you return home with unsold pigs? 1 = Yes ( ), 2 = No ( )

31. If yes do you have place to quarantine the animal until 14 days 1 = Yes ( ) 2 = No ( )

32. If it is live animal what is the selling price?

1 = 80,000 - 100,000 ( ), 2 = 100000 - 200,000 ( ), 3 = >200,000 ( )

33. What are means of transaction?

1 = Cash ( ) 2 = Paid later, 3 = Advance payment ( ), 4 = 1 and 2 ( ) 5 = Barter trade ( )

34. Do you slaughter animal? 1 = Yes ( ) 2 = No ( )

35. If Yes to 35 where do you slaughter animals?

1 = at farmers home ( ), 2 = at government slab ( ), 3 = at private slab ( ), 4 = backyard ( ) 5 = others (specify)

36. Do animals inspected each time before slaughtered? 1 = Yes ( ) 2 = No ( )

37. What is the slaughter value of a health animal?

1=100,000 ( ), 2=150000 ( ), 3= 200,000 ( ) 4= other specify\_\_\_\_\_

38. How do you disposal waste products

1= offered to farmers ( ) 2 = dump garbage ( ) 3 = deep burial ( ), 4 = burning ( ) 5= others specify \_\_\_\_\_

39. Where do you buy meat?

1= at slaughter slab ( ), 2= butcher ( ), 3 = at farmer's home ( ), 4= other specify

40. Quantity of meat bought in kilogram? \_\_\_\_\_

1= 5 – 10 ( ), 2= 10 – 20 ( ), 3= 20 – 30 ( ), 4= 40 -50 ( ) 5= >50 ( )

41. What is the buying price? (TZS)

1=1000-3000 ( ), 2 =3500 – 5000 ( ), 3=>5000 ( )

42. What is the selling price? \_\_\_\_\_ (TZS)

1=1000-3000 ( ), 2 =3500 – 5000 ( ), 3=>5000 ( )

43. How do you handle waste product?

1= deep burial ( ), 2 = offer leftover to farmers ( ), 3 = damp ( ) 4 = burning ( )  
5=others specify

### SECTION C: MARKETING COSTS FOR PIG ENTERPRISE IN 2017

44. Indicate the marketing cost incurred in the table below

Item	Unit price	Quantity	Costs
Charcoal			
Fire wood			
License			
building rent			
Salary of workers			
Municipal/Village fee			
Fuel and Oil costs			
Sanitary fee			
Security bill			
Water bill			
Electricity bill			
Freezer			
Gas costs			
Others			

**Section D: Marketing Constraints**

45. What challenges did you face in the last 12 months in pig production and marketing??

Please give your ratings 1 (low) to 5 (high) for the questions below:

Challenges	Response
Inadequate of knowledge about end consumer	
Inadequate of capital to expand business	
Inadequate of access to inputs	
Inadequate of exotic breeding stock	
Unreliable market	
Theft of animals	
Diseases and pests	
Inadequate of livestock extension staff	
High price of inputs	
Price uncertainty	
Lack of credit facilities	
Poor measurements system	
Lack of modern slaughter facilities	
Conflict with neighbours	
Low demand for feeds	

**Section E: Membership In Farmers Organization**

46. Have you joined any trader's organization dealing with agriculture/ livestock?

1= Yes ( ), 2 = No ( )

47. If YES, what is the name of the organization? \_\_\_\_\_

48 When did you joined the organization \_\_\_\_\_ (Year)

49. If no to 48 please give reason?

1= lack of information ( ), 2=too cost ( ) 3= no interest ( ), 4= not available within village ( ) 5=not well organized ( ), 6= only few benefits ( ), 7 = others specify

\_\_\_\_\_

50. What services do you get from the organization? 1= for sell products ( ) 2= training and veterinary services ( ) 3= Provision of loan ( ) 4 =Input supply ( ) 5 other specify \_\_\_\_\_

51. What are benefits of joining farmer organization?

1= Market information ( ) 2=loan accessibility ( ) 3= training session ( ), 4= low price of inputs ( ) 5=profitability ( ), 6. Advisory service ( ) 7= other specify

### Section G: Disease Information

52. How long have you been in the pig farming? \_\_\_\_\_ (Year)

53. Do you know African swine fever disease? 1= Yes ( ) 2 = No ( )

54. Do you have other names for African swine fever? Please mention \_\_\_\_\_

55. If yes to G1. 2 what are the source of disease information?

1= TV ( ), 2 =radio ( ), 3= newspaper ( ), 4= mobile phone ( ), 5= veterinary officer ( ) 6= animal markets ( ), 7=fellow farmer ( ) 8= friend ( ), 9= others (specify)

56. When was the outbreak started? \_\_\_\_\_ (Month and Year)

57. When was the outbreak stopped? \_\_\_\_\_ (Month and Year)

58. What was total expenditure on ASF control? \_\_\_\_\_ (TZS)

59. Before outbreak what was the price of live animals? \_\_\_\_\_ (TZS)

59b.Before outbreak what was the price of meat? \_\_\_\_\_ (TZS)

60. During outbreak what was the price of live animals? \_\_\_\_\_ (TZS)

60b.During outbreak what was the price of meat? \_\_\_\_\_ (TZS)

61. How many live animals did you buy during outbreak? \_\_\_\_\_

62. During outbreak did the government restrict trading of pigs?

= Yes ( ), 2 = No ( )

63. If yes to 62. How much did you lose during outbreak? \_\_\_\_\_

64. Did you close your shop? 1= Yes ( ), 2 = No ( )

65. IF yes to 64 for how long did you close?

1= 1 -2 month ( ) 2 = 2 – 3 months ( ) 3 = >6 ( ) 4= never return ( )

### G4: Diseases Mitigation

66. During outbreak which of the following action did you take?

1= no action ( ), 2= call village vet ( ), 3= selling only health animal ( ), 4=selling both sick and health animals ( ), 5= selling only sick animal ( ) 6= buying sick/infected animals ( ), 7= others specify

67. What measures did you adopt to control the disease?

1= quarantine ( ), 2= slaughter of animal ( ), 3=no action ( ), 4= stop doing pig business ( ) 5= quickly selling of pig ( ), 6=others specify

68. Please mention factors that hinders the mitigation of ASF

1= illegal livestock movement ( ), 2= low biosecurity level ( ), 3 = lack of awareness ( ) 4=late reporting of disease ( ) 5= lack of training on animal disease management ( ), 6=lack of cooperation ( ) 7.lack of compensation scheme ( ), 8= specify

**THANK YOU FOR YOUR COOPERATION**

**Appendix 4: Checklist during direct observation to assess the risk practice and behaviours that increase the risk of ASF disease**

**REGION:** .....

**WARD:** .....

**VILLAGE:** .....

<b>Na</b>	<b>Farm level</b>	<b>Remarks</b>
1.	Cleaning and disinfection of equipment and material	
2.	Presence of fences to keep wildlife out of contact with herds	
3.	Present of tick in pig premises	
4.	Farmers sharing equipment's	
5.	Disposal of waste product	
6.	Movement of visitors near pig herds	
7.	Water in container/feeder	
	<b>Slaughter infrastructure</b>	
8.	Floor surface	
9.	Buildings	
10.	Roof	
11.	Water supply	
12.	Slaughtering facilities and the frequency of use (type of slaughtering facility)	
13.	Cleaning facilities (supplies of detergents, disinfectants, etc)	
	<b>Human health protection</b>	
14.	Hand washing facilities	
15.	Provision of masks and/or gloves	
	<b>Transportation of animal and product packaging</b>	
16.	Means of transportation	
17.	Average number of animals transported per vehicle	
18.	Cleanness and Disinfectant of vehicle used to carry animals	
19.	Health checking of purchased stock	
20.	Regulation of animal and product movement with certification and enforcement of checks	
21.	Measures to ensure traceability of livestock: identification and registration (IandR)	
22.	Veterinary inspection/health checks at markets	
23.	Packaging material for products	

**Appendix 5: Key informant’s guide**

**Part A: Respondent Particulars**

Name of respondent: .....

Date of interview: ...../...../20.....

Occupation: .....

Region: .....

District: .....

Ward: .....

Village: .....

**Part B: Key Participant and Activities in Pig Value Chain**

1. What are core processes in pig value chain?

.....  
.....

2. Who are main actors in pig value chain in study areas?

.....  
.....

3. What are specific activities performed by each actor?

.....  
.....

4. What are output products?

.....  
.....

5. Indicate the flow of product from production to final consumer

.....

6. What kind of relationship and linkage actors have to each other?

.....  
.....

7. What are rules and regulations in pig value chain?

.....  
.....

8. What incentives could motivate actors in pig value chain?

.....  
.....

9. What socio-economical forces that affect pig value chain performance?

.....  
.....

10. What are the cultural practice of actors in pig value chain?

.....  
.....

11. How does climate change influence flow of pig products?

.....  
.....

12. What are constraint in pig value chain?

.....  
.....

**Part C: Disease Information**

13. When was the last time ASF occurred in your area?

.....

14. In your opinion what are the main sources of ASF outbreak in your area?

.....  
.....

15. How do you get the information about ASF outbreak?

.....  
.....

16. Do actors in pig value chain know about ASF? 1=Yes, 2 = No

17. How actors in pig value chain react during ASF outbreaks?

.....  
.....

18. In your option which node contribute high to occurrence of ASF outbreak?

- 1. Famers, 2. Input suppliers 3.Pig collectors 4.Traders 5. Consumers

19. Please give reason for your selection in question above

.....  
.....

20. In your option which node is affected more during outbreak? and explain why

- 1. Famers 2. Input suppliers 3.Pig collectors 4.Traders

21. Do you offer compensation scheme to farmers who lose their pigs? 1= yes 2= No

22. How do actors in pig value chain control diseases outbreak in your area?  
.....  
.....
23. In your opinion what should be done to prevent ASF outbreak in your area?  
.....  
.....
24. Do animal movement policy regulation applicable in your area? 1= yes, 2= No  
24b. If No to 27 please explain  
.....  
.....
25. Is there any routine screening and prevention of diseases? 1=Yes 2= No  
If yes, mention screening and prevention measures for ASF disease  
.....  
.....
26. In your opinion what hinders prevention and control of ASF in your area?  
.....  
.....

***THANK YOU FOR YOUR TIME***