POTENTIAL ROLE OF SOCIAL NETWORKS IN CONTROLLING AFRICAN SWINE FEVER ON THE KENYA-UGANDA BORDER

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university

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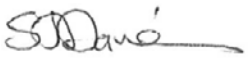

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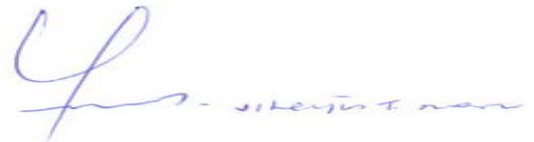

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DEDICATION

This thesis is dedicated to the Almighty GOD who availed this opportunity in His timing, to my husband Jonathan Orengo for his encouragement to read until I get professorship and my children Lenny, Keller and Cephas for their support and blessings to be away from home.

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LIST OF ABBREVIATIONS

AHSPS	Animal Health Service Providers
ASF	African swine fever
AusAiD	Australia Aid
CRP	Coordinated Research Program
CSIRO	Common Wealth Scientific Industrial and Research Organization
CSSHREC	Common Wealth Scientific Industrial and Research Organization - Social Science Human Research Ethics committee
DNA	Deoxyribonucleic acid
DVS	Department of Veterinary Services
FFS	Farmer Field School
FC	Farmers Choice
FAO	Food and Agriculture Organization of the United Nations
HIV-AIDS	Human Immunodeficiency Virus-Acquired Immune deficiency Syndrome
ID	Identification.
ILRI	International Livestock Research Institute
MAIF	Ministry of Agriculture, Industry and Fisheries
MOLD	Ministry of Livestock Development
NAADS	National Agricultural Advisory Services
NGO	Non-governmental organization
OIE	World Organization for Animal Health/Office International des Epizootics
SNA	Social Network Analysis

SACCO	Savings and credit cooperative organization
SSREC	Social Science Human Research Ethics committee

ABSTRACT

A social study on the epidemiology of African Swine Fever (ASF) was carried out in Busia County, Western Kenya and the adjacent Busia and Tororo districts of Uganda. The objective was to explore the value of social network analysis in informing options for effective intervention in the control and future eradication of ASF. To achieve this objective, data were obtained from a cross sectional study of smallholder pig-keeping households and follow-up studies carried out on traders and animal health service providers. Data was collected through a structured questionnaire. Villages were the primary sampling units and households (in selected villages) were the secondary sampling units. Selection of village clusters was by spatial random sampling executed using GIS and the 2008 Kenyan and 2010 Ugandan administrative boundaries. In the selected villages, pig keeping households were generated by village elders and chiefs and households were randomly selected from the list thus household selection was by stratified random sampling.

The cross sectional study involved representatives from 683 households in four districts interviewed between July and November 2012 and two follow up studies carried out between February and May 2013 on 120 households. Extended social network interviews for the traders and animal health service providers were carried out between May and September 2013.

Data was analysed using Statistical Package for the Social Sciences (SPSS) version 21.0 and Microsoft Excel for analysis. Vensim personal learning edition was used to model pig dynamics in the study region. Social network data were analyzed using the computer package NodeXL (Hansen and Shneiderman 2009).

Pig rearing had the potential to raise the income of resource-poor farmers. Sale of pigs enabled households pay school fees, purchase farm inputs and pay hospital bills among other needs. Start-up capital for pig keeping was low (KSh 500) and pigs required minimal rearing space compared to other large livestock. Pig numbers were more during the wet seasons but most sales by households occurred during Christmas, opening of school term and when there were rumours/outbreaks of ASF. There was a high pork demand during dry months when there was decreased food availability in the households. There was no organized pig marketing system and transportation of pigs was mainly by motorcycles or trekking. Households in Kenya (81.5%) and Uganda (89.1%) had heard of ASF, but facts on the disease were scanty. The animal health service providers' number was inadequate and they were not competent in treating pig diseases. The association of ASF outbreaks with the swamp on Malaba river in Buteba County Uganda needs further research. Pig feed was a major challenge but disease was deemed a major risk to pigs, particularly ASF. There were no laboratory services to confirm clinical diagnosis of pig diseases. The ELISA results from the 1428 (1057 cross sectional and 371 follow up) pig samples collected during the study showed that there was no virus circulation in the blood system but ASF virus was detected by PCR in the spleen of one of the sentinel pigs. There was an association between frequent pork consumption and ASF infection, ($P<0.05$, $\chi^2 = 6.6$). Feeding pigs on household food leftovers when obtaining pork from unlicensed sources was also associated with ASF outbreaks, ($P<0.05$, $\chi^2 = 8.56$). Households inconsistently treated for external parasites and some took pigs to swampy areas to wallow in mud. Pig faeces when composited by households and used as manure exposed pigs to risk of ASF. There was panic sale of pigs by households during rumours or outbreaks of ASF and continued pig trade even when quarantine was imposed. There was unregulated slaughter of pigs and sale of pork by traders. The pig movement and

trade networks were localized and based on underlying close social networks; family ties, friendship and neighbourhood. The pig movement and trade networks modularity ranged from 0.2 – 0.5 showing good community structure within the network implying faster and easier flow of knowledge, adoption of attitudes and beliefs and also faster rate of disease transmission. The average path length of 5, meant disease would easily reach every node in a cluster. Demonstration was noted as a powerful tool in adoption of new practices and already existing organizations among the pig value chain actors could be used to support knowledge dissemination. Information was most sought from Local FM vernacular radio stations and local leaders. There were weak linkages between private animal service providers with the veterinary authorities and also between traders and veterinary authorities. The follow up study results confirmed that pig farming was a localized trust-distance-relationship enterprise by smallholder farmers that required very minimal start-up capital with minimal production costs. There was a weak farmer-animal health service provider linkage and smallholder farmers trusted the local leaders for advice and help.

There is need for development of an all inclusive ASF control strategy. Messages on ASF control can effectively be channeled through the already established trust networks. Platforms for information exchange that include demonstrations are effective to adoption of practices. There is need for establishment of standard slaughter and marketing facilities. Linkages between the private animal health service providers and the government veterinary authorities need to be strengthened. Cross-border harmonization and coordination of ASF control strategies between Kenya and Uganda need to be strengthened. Social science studies as relates to disease transmission should be included in the veterinary training curriculum. The most critical point in the control of ASF was the marketing stage that is controlled at farm level.

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Background

African Swine Fever (ASF) is an infectious disease of domestic and wild pigs. It affects animals of all breeds and ages. The disease is caused by a large Deoxyribonucleic acid (DNA) virus classified in the monotypic family *Asfaviridae*, genus *Asfivirus* (Dixon *et al*., 2005), that produces a range of symptoms and signs and is characterized by high morbidity and mortality (Hess, 1982). Studies carried out in Kenya and Uganda have been geared towards characterizing the ASF virus serotypes that cause outbreaks in the domestic and wild pigs. It has been widely thought that spread is by movement of pigs and pig products. Control measures have been geared towards controlling pigs and pig products movement. However, the control measures put in place in the past have not been effective in controlling outbreaks and disease spread. African swine fever outbreaks have continued to be experienced over the years in Kenya (DVS, 1994, 2001, 2012) and Uganda (OIE, 1996-2014)

The International Livestock Research Institute (ILRI-Kenya)–BecA Hub in partnership with Commonwealth Scientific and Industrial Research Organization (CSIRO) implemented the project: “Understanding the epidemiology of ASF as a prerequisite for mitigation of disease impact on pig-keeping in East Africa.” One of the objectives of the project was to investigate whether social networks played a role in the epidemiology of ASF. The study of human behaviour was carried out using social network analysis to explore the nature and extent of the contacts between animals or farms for a better understanding of the potential risk for ASF disease spread in susceptible populations.

Social Network Analysis (SNA) approach has been used to explore the nature and extent of contacts between animals or farms (Martı´nez-Lo´pez *et al.,* 2009). A social network generically refers to a group of elements and the nature and extent of the connections, relationships, or interactions between and among them (Martı´nez-Lo´pez *et al.,* 2009). The networks are potential starting points for collective efforts on ASF biosecurity, other pig production constraints (e.g. feed availability) and stronger market chains. Analysis of social networks provides both visual frameworks of the relationships and the flow of knowledge and resources between people, groups and organizations involved in the pig enterprise (Clottey *et al*., 2007).

The proposed study was designed to identify relationships that may play a role in accelerating the spread of ASF within Kenya and across the border with Uganda. The study was conducted in Busia County, Western Kenya and the adjacent Busia and Tororo districts of Uganda. Most outbreaks in Kenya were believed to originate from the Kenya-Uganda border (DVS, 1994). Western Kenya and in particular Busia County, is frequently affected by ASF outbreaks resulting into higher case fatalities compared to other areas (DVS, 1994, 2001,2012).

1.2 General objective

The overall objective was to assess how social networks can inform options for efficient and effective intervention in the control and future eradication of ASF along the Kenya-Uganda border area.

The specific objectives were to:

1. Assess knowledge about pig keeping, trade and ASF disease in Busia County Kenya, Busia and Tororo districts Uganda; and their contribution to ASF epidemiology,

2. Determine the pig husbandry and trade practices and potential risks of ASF virus introduction and spread in the study area,
3. Determine the social networks of pig keeping households, traders and service providers in the study area and their potential contribution to ASF introduction and spread,
4. Asses sources of advice and trust of pig keeping households and traders in Busia County Kenya, and Uganda Busia and Tororo districts.

1.3 Justification

Pig rearing has a considerable potential for raising incomes of resource poor farmers while it can also improve direct consumption of white meat increasing access to high levels of protein. Current reasons for pig-keeping, especially for the small-scale and backyard farming systems, include pork production and income generation. Pigs are an asset representing a store of wealth or safety net in times of crisis. African swine fever disease causes serious socio-economic losses to the pig value chain actors and has threatened the livelihoods of these actors in terms of poverty alleviation and food security that is based on short-cycle livestock species of which pigs are the most prolific. African swine fever outbreaks have threatened export of pig products thus lowering foreign exchange earnings (DVS, 1994, 2001, 2012). Although new approaches to vaccine development have been initiated, none is available yet for use. Several control measures have been instituted including public awareness on proper husbandry methods and pig and pig products movement control. All these measures have not curbed outbreaks and spread of ASF in the past.

To enable Kenya and Uganda design an effective control and eradication strategy for ASF, it was important that a study on the role of social networks be undertaken to complement past and ongoing epidemiological and diagnostic studies. The key beneficiaries of a control and

eradication strategy recommended by this study will include pig farmers, farmer groups, traders, women and children, feed manufacturers, consumers and the veterinary authorities in Kenya and Uganda.

1.4 Thesis structure

Chapter one of the thesis gives a background of the study and points out that the control of ASF disease has not been successful inspite of all past efforts since its first reports in Kenya in 1921. This chapter also highlights the objectives of the study.

The importance of the study is elaborated in Chapter 2 i.e. literature review, where a background of the pig industry, ASF outbreaks and the impact of ASF on livelihoods has been highlighted. This chapter also brings into perspective how social networks knowledge has helped in better understanding of disease spread in other studies. Chapter 3 of the thesis records the materials and methods used in the study. Chapter 4 discusses the current knowledge about pig keeping. Market dynamics of pigs and also what is known about ASF by the pig keeping households, traders and the animal health service providers.

Chapter 5 discusses the risk factors in the study area and how they contribute to the introduction and spread of ASF. Chapter 6 discusses the pig movement and trader networks in the study area and how they are important in ASF epidemiology. Chapter 7 discusses the advice and trust networks of the pig keeping households and traders. This chapter highlights the importance of these networks and how they can be used in information dissemination and influence about ASF. Chapter 8 gives the results of the follow up study and confirms the cross-sectional study results. Chapter 9 is the conclusion of the study and suggests recommendations that should be considered to improve the surveillance of ASF and therefore control.

CHAPTER TWO

LITERATURE REVIEW

2.1 The livestock sector in Kenya and Uganda

The livestock sector in Kenya comprises 17.5 million cattle, 17.1 million sheep, 27.7 million goats, 2.9 million camels, 334,600 pigs, over 31.8 million chicken 1.8 million donkeys and 470,000 rabbits all valued at about KSh 700 billion (KNBS, 2009). Sales from Kenya's livestock produce is valued at KSh 302.9 billion annually of which KSh 37.6 billion (12%) is from pig meat (DLP, 2008). During the years from 2000 to 2005, the number of pigs reduced from almost 420,000 (in 2000) to 320,000 in 2005, with an average of around 370,000 pigs (MOLD, 2010). In Kenya, pig production takes place mainly in Western, Rift Valley, Nyanza, Eastern, Central and Nairobi Provinces. Most vulnerable households have adopted small-scale pig farming to improve their living standards (FAO, 2012). In Western and Nyanza regions where free range pig production is predominant, the human development index is low and prevalence of poverty and HIV/AIDS is high (FAO, 2012).

The agricultural sector in Uganda is an important sector of the economy contributing up to 23.8 % of the GDP and generating about 48% of export earnings. About 4.5 million households (70.8%) rear at least one kind of livestock/poultry. The livestock population in 2008 as per the Uganda bureau of statistics (2008) was 67,900,000 with a pig population of 3,184,000. In 2011, Uganda had the highest per capita consumption of pork in sub-Saharan Africa (3.4 kg/person per year) (www.pigfarmers.co.ug). Pig production is widespread and is increasing at a high rate. About 17.8 % (1.1 million) of all households own at least a pig. The pig population has been increasing over the years from 187,100 in 1980 to 3,182,000 in 2008 (Danilo, 2013) that gives an indication to a rapidly growing sector and increasing demand for pork.

2.2 Pigs as source of livelihood

Smallholder pig farming is an important livelihood source in many households in rural Western Kenya (FAO, 2012). The pigs are sold to earn household income which is in turn used to buy food, pay school fees and medical bills (Mutua *et al*., 2011a). Pig rearing in Kenya is becoming a lucrative enterprise especially for women and youth. The pig production systems range from large scale fully commercial intensive production systems, e.g., Farmer's Choice (FC), to back-yard and free-range farming systems. The back-yard and free-range farming systems are characterised by low input-low output and poorly managed pig production enterprises (FAO, 2012). The small scale producers keep on average 2-5 pigs under very poor hygienic and management conditions characterised by low biosecurity (FAO, 2012). Pigs are preferred by poor households because of fast growth and high fecundity with low initial and maintenance cost, requiring little in investment on feed. The productivity of pigs is determined by the breed and overall husbandry management. Well managed breeding sows of improved breeds will farrow twice a year and provide approximately 10 piglets per litter or 20 piglets/year. Weaned piglets (1 month old) can be sold for income generation and/ or fattening can be performed on farm, allowing the farmer the option to choose the time of slaughter/ selling, for example, when prices are favourable (Klaas, 2011). Unlike the other livestock that depend on weather conditions, e.g., availability of pasture for survival, pigs are scavengers, reared within a small area and they mature faster.

2.3 African swine fever

African swine fever is a major limiting factor for pig production in most of the countries in Africa (Jori *et al*., 2012; Fasina *et al.*, 2012) and the world (CIRAD, 2013). The causal agent for ASF is a large Deoxyribonucleic acid (DNA) virus classified in the monotypic family

Asfaviridae, genus *Asfivirus* (Dixon *et al*., 2005). Infection with ASF virus produces a range of symptoms and signs in domestic and wild pigs of all breeds and ages. Acute disease is characterized by high fever, hemorrhages in the reticuloendothelial system, and a high mortality rate (Van der Valk**,** 2008). The virus is very hardy, persisting for months in pig faeces, dead pigs, offal, pig meat and pig meat products (OIE, 2008), where it might potentially infect other pigs several months later if it is in fresh, salted dried-pork products and in the environment. The African swine fever virus is highly resistant to environmental conditions. It can survive for a year and a half in blood stored at 4º C, 11 days in faeces at room temperature, and at least a month in contaminated pig pens. The virus will also remain infectious for 150 days in boned meat stored at 2.8º C, 140 days in salted dried hams, and several years in frozen carcasses (www.cfsph.iastate.edu, 2010)

African swine fever was first reported in Kenya in 1921 as an entity distinct from classical swine fever (Penrith and Vosloo, 2009) and its first description from South Africa was published in 1928. The disease has since spread to Portugal in (1957 and 1960) and rapidly to several European countries and it is now endemic in the Italian Island of Sardinia (Penrith and Vosloo, 2009). African swine fever is endemic in many countries in sub-Saharan Africa (FAO, 2000; Penrith and Vosloo, 2009).

Kenya did not experience ASF outbreaks for three decades since 1963 until an outbreak occurred in 1994 (CIRAD, 2013) in small scale pig farms in Kiambu, Thika, Kajiado and Nairobi (DVS, 1994). The next outbreak occurred in 2001 in medium to large scale pig farms in Nairobi, Kiambu and Thika. This outbreak was traced to infective swill derived from pork imported from Uganda illegally into Kenya (DVS, 2001). Another outbreak occurred in November 2006 – 2007 with much wider spread in Nairobi, Thika, Kiambu, Nakuru, Kericho,

Eldoret and Busia. Since December 2010, there have been outbreaks in Kakamega, Kisumu, Thika, Kiambu, Nairobi and Mombasa and the outbreaks are still ongoing to date (DVS, 2012). The country has been experiencing shorter inter-epidemic periods of ASF in the recent past. Uganda has reported ASF outbreaks since 1996. There were 7 cases reported to the OIE in 1997 and the number of outbreaks increased each subsequent year with the highest number of outbreaks (57 outbreaks) reported in 2002. The outbreak number reduced from 45 in 2003 to 1 in 2010. In 2011, there was a rise the number of outbreaks to 10. There was no available information about ASF disease situation from 2012 to 2014 though it is presumed that some areas experienced outbreaks but did not report thus were not documented. Most outbreaks occurred in the central and eastern regions of Uganda (OIE, 1996-2014).

2.4 The impact of African swine fever

African swine fever is classified as a notifiable disease (must be reported to OIE when it occurs in a country) of domestic pigs by the World Animal Health Organization (OIE) because it is a transboundary disease and the sanitary and socio-economical consequences have a significant impact on the national and international trade of pig and pig products (Sánchez-Vizcaíno *et al.,* 2009). The major limiting disease for rearing and selling pigs in Kenya and Uganda has been ASF. When outbreaks occur, countries that import pig products from Kenya and Uganda impose a ban on exports until the countries are declared free of the disease. The disease also constrains retail business because of the erratic number of pigs for slaughter during outbreaks (Kagira *et al.,* 2010a). During ASF outbreaks, the smallholder pig keepers lose an asset/investment that usually represents a store of wealth or safety net for times of crisis (FAO, 2012). The greatest losers during an ASF outbreak are usually the poorer pig producers who are less likely to implement effective prevention and control

strategies or basic biosecurity (Solenne *et al*., 2009). In countries such as Cote d'Ivoire and Madagascar, the introduction of ASF resulted in the loss of between 30 and 50 per cent of the pig population (Solenne *et al.,* 2009). The introduction of ASF into countries outside Africa has led to high mortality rates, loss of status for international trade and the implementation of drastic and costly control strategies to eradicate the disease (Solenne *et al*., 2009). The disease is endemic in most sub–Saharan Africa countries including the island of Madagascar. The highest incidence of disease is seen from the equator to northern Transvaal. Outside Africa, ASFV is endemic in feral pigs in Sardinia, Italy. It was also introduced into the Caucasus in 2007, and has apparently become endemic among wild boars in the region. The virus has caused outbreaks among domesticated swine in the Republic of Georgia, Russia, Armenia, Azerbaijan and other countries in the region (www.cfsph.iastate.edu/llCAB, 2010). Currently there is neither treatment nor a vaccine for ASF globally.

2.5 Transmission of African swine fever

African swine fever can be transmitted by direct contact with infected animals, indirect contact with fomites, and tick vectors (www.cfsph.iastate.edu/llCAB, 2010). Pigs usually become infected via the oro-nasal route by direct contact with infected pigs or by ingestion of waste food containing unprocessed pig meat or pig meat products. Pigs infected with less virulent isolates can transmit virus to susceptible pigs as long as one month after infection; Blood is infectious for as long as 6 weeks, and transmission can occur if blood is shed. Pigs that survive infection with the less virulent isolates may be persistently infected and have circulating antibody, although they do not excrete virus or transmit virus but their role in the epidemiology of the disease is not fully understood (Fasina *et al.,* 2012;Oura, 2013). Environmental contamination may occur if blood from infected pigs is shed during

necropsies, or if a pig develops bloody diarrhoea. The virus can also spread on fomites, including vehicles, feed and equipment (www.cfsph.iastate.edu/llCAB, 2010). Spread of virus also occurs when veterinarians move from farm to farm without observing biosecurity measures during outbreaks when called upon to treat pigs (Fasina *et al.,* 2012). As long as infective virus is present in the environment, traders who look for pigs from farm to farm and even the farmers'/people movement to and from farm/slaughter slabs can facilitate disease spread. Much of the risk of livestock disease spread is associated with animal, animal product movements and interaction of value chain actors, which are mostly amenable to analysis using social network tools. Pathogens can spread between animal holdings both through direct animal contact and indirect contacts such as persons, vehicles, equipment and products of animal origin (Lindstrom *et al.,* 2009). These contacts are through activities that are most times overlooked when disease control strategies are being implemented. Social networks combine knowledge of the usual patterns of movements of animals, products, materials and people with risk analysis to better understand how disease could spread if introduced into a system at different places (FAO, 2011).

2.6 Control of African swine fever

Implementation of biosecurity measures plays a major role in preventing introduction of disease to free countries. Though this has been successful in some instances, ASF virus has continued to spread (Carlos, 2009; Fasina *et al.*, 2012) and remains a threat to the growing pig industry worldwide considering the fact that the world is becoming a global village, individuals trot the world within a short period and they could be a source of infection to newer areas. The disease is being detected in new frontiers year by year becoming a global threat (Sánchez-Vizcaíno *et al.,* 2009; Solenne *et al*., 2009). Once introduced in an area, stamping out is almost impossible. A concerted effort to disease control and later eradication

in endemic countries is important in bringing an end to this global threat. Many countries have developed regulations that require farmers to report livestock movements to authorities because research has shown that movement of livestock is a key factor in the spread of infectious diseases. Kenyan and Ugandan policies for ASF control include: public awareness on proper husbandry methods; pig and pig products movement control; improved biosecurity (confining infection at source); and management of offals. Implementation of biosecurity practices (hygiene and good management) reduces the risk of pig exposure to ASF virus (Fasina *et al.,* 2012). These methods offer the best option in mitigating the impact of ASF on producers and other value chain stakeholders in the short term. Incidentally, farmers lack adequate knowledge and resources for improved pig management and disease control (Mutua *et al*., 2011a).

2.7 Social networks and general disease spread

Social network analysis focuses on the "*relationships* among social entities, and on the patterns and implications of these relationships" (Wasserman & Faust, 1994). The use of SNA in epidemiological research began when inadequacies were highlighted by HIV-AIDS, in representing the social structure of populations and patterns of social interaction through which infective agents spread (Klovdahl *et al.,* 1994). While the long established equation-based approach to epidemiology, built on the SIR model (S-susceptible, I-Infected, R - Recovered), provides rigorous results given sufficient data on variables affecting infection and recovery rates, it does not provide for analytical treatment of complex scenarios with multiple transmission pathways and incomplete or uncertain knowledge of transmission risks and rates (Skvortsov *et al*., 2007). Epidemiological research has engaged with SNA to develop better predictive models of disease transmission and inform effective strategies for

intervention and control (Klovdahl *et al.*, 1994; Woodhouse *et al.*, 1994; Rothenberg *et al.*, 1998; Martı´nez-Lo´pez *etal.*, 2009).

Social network analysis is proving to be an important tool for identifying paths for transmission of infectious diseases amongst livestock (Guillaume *et al.*, 2013). Networks and linkages in value chains that link production systems, markets and consumers constitute a contact network for contagious diseases and provide opportunities for transmission of disease within and between sectors (FAO, 2011). Networks provide a conceptual framework that can express relationships between constituent elements (Bigras-Poulin *et al.*, 2006). The first substantial application of SNA in an animal disease context was ex-post investigation of how the 2001 UK Foot and Mouth Disease outbreak spread (Shirley and Rushton, 2005; Ortiz-Pelaez *et al.*, 2006). Social network analysis has since been used in Denmark where cattle movements over a 179-day period and swine movements over a 232-day period in Denmark in 2002–2003 were studied (Bigras-Poulin *et al*., 2006, 2007). A small proportion of movements were long distance movements. Use of SNA in preventive veterinary medicine also appears to be expanding, being used to identify populations and areas at risk for disease introduction and dissemination (Martı´nez-Lo´pez *et al.*,2009). Social network analysis is also increasingly being applied to understand the diffusion of information through interpersonal communication, such as promoting preventive health behaviours (Valente and Fosados, 2006). Such research builds on the recurring view within public health domains in particular also applied in association with product marketing, that attitudes, beliefs and behaviour are transmitted between people much like communicable diseases, through a process of social contagion (Christakis and Fowler, 2013). While social contagion does not explain all processes of adoption of innovation or social change (Alvergne *et al.*, 2013) it does highlight that social networks that are important in livestock disease control are not only those

related to livestock movements but also those that influence people's adoption of attitudes and behaviors that could reduce the risk of disease transmission. The SNA approach is based on the study of the relationships among social entities, and on the patterns and implications of these relationships (Wasserman, 1994).

The SNA tool is increasingly becoming important in characterizing networks that result from movement of livestock from farm-to-farm and through other types of farm or household operations. It is a powerful tool that is being used to study the relationships created among these operations, providing information on the role that they play in acquiring and spreading infectious diseases, information that is not readily available from traditional livestock movement studies (Dube *et al.,* 2009, 2011). In addition, SNA provides both visual and mathematical analysis of the relationships and the flow of knowledge and resources between people, groups and organizations involved in an enterprise (Clottey *et al*., 2007). In epidemiology the great conceptual strength of networks is that they provide information that not only impacts animal movements *per se* but also the relationship between these movements that produce paths (Christley *et al*., 2003). These paths can be followed by pathogens in a disease and/or infection transmission process, usually called the direct transmission route. Social networks have been used to explore how disease can spread between animal establishments through contact networks of personnel who work in these establishments. This was demonstrated among race horse trainers in Great Britain during a week of competitions to determine the level of connections among trainers through co-attendance at races (Christley *et al*., 2003).

Several studies have provided information about the characteristics of some livestock movement networks, the types and uses of network analysis measures and the impact that the

network structure can have on how we think about and control highly contagious diseases (May and Lloyd, 2001; Kiss *et al.,* 2005, 2006a,b,c; Saramaki and Kaski, 2005; Shirley and Rushton, 2005b; Woolhouse *et al.*, 2005; Green *et al.*, 2006; Kao *et al.*, 2006, 2007; Duerr *et al.*, 2007; Pautasso and Jeger, 2008). Webb (2005, 2006) and Webb and Sauter-Louis, (2002) studied the contacts among sheep flocks in Great Britain through farmers attendance of different shows. The study showed that farmers who attended the same shows represented an opportunity for infectious diseases to spread rapidly through Great Britain during the summer months thus the shows linked the farms together. The farmers were found to travel long distances to attend shows thus restricting attendance geographically to 'local shows' would be the optimal strategy to prevent the long distance spread of infectious diseases in sheep. The study of movements of cattle accross livestock operations such as farms, markets and dealers in year 2002 (Christley *et al*., 2005), a series of measures such as 'betweenness' and 'farness', were obtained to identify livestock operations of importance in the flow of animals in the network and operations with high in-degree and out-degree values.

Highly connected livestock operations were shown to be very important to identify in advance of disease incursions so they could be targeted for education and also for rapid intervention during epidemics. Livestock markets were one of such highly connected operations with high betweenness, along with livestock dealers and even some individual farms (Bigras-Poulin *et al*., 2006, 2007) and the spread of Avian influenza in China (Martin *et al.,* 2011). Christley *et al*. (2005) found that markets and dealers had a vast number of incoming and outgoing connections. The markets and dealers were important in linking pairs of operations in the network by having a central place in the flow of animals. Markets were also highly connected because of their high in- and out-degree values, which made them important for building

communication pathways and for information dissemination among the livestock industry (Robinson and Christley, 2007).

Detailed knowledge about behaviour of people involved in all stages of livestock production from farm to consumer is essential (FAO, 2011a). A study of social networks combines value chain analysis with risk analysis so that decisions can be made taking into account how the behaviours of different people involved in the value chain affect disease risk as well as the effects of livestock disease and its control measures on those people (FAO, 2011). Studies of livestock movements in the context of network analysis supports the need to understand the contact patterns of susceptible populations before embarking on any strategy for disease control (Dube *et al.,* 2009). In this case, social networks also goes a step further to pay attention to the behaviour and motivations of the people involved. Understanding of the people, groups or organizations involved in the livestock sector, how they operate and what their constraints are in terms of regulations allows the impact of control measures on stakeholders to be assessed so that the resultant strategy can take into consideration the knowledge, perceptions, behaviour and reactions of people, (The strategy is both risk based and people-centered). The study of networks of livestock movements and other types of contacts among livestock holdings in the population provides extremely important information that is relevant to decision-makers in the development of appropriate response strategies against highly contagious diseases (Dube *et al*., 2009; Bigras-Poulin *et al*., 2006, 2007).

For better planning, social networks can be engaged in absence of disease to help animal health advisors anticipate how chains may react in the presence of disease. Looking at past movements to extrapolate what might happen in the future reveals which node in networks

monopolize and the number of contacts a node may have (Christley *et al*., 2005; Bigras-Poulin *et al*., 2007). A social network map involves nodes and ties. Nodes are entities which can be individual actors, places, agents of interest while ties are relationships between the entities.

CHAPTER THREE

GENERAL MATERIALS AND METHODS

3.1 Background

This work was part of the larger AusAID-CSIRO-BecA-ILRI project; *"Understanding African swine fever as a prerequisite for mitigation of disease impact on pig keeping in East Africa."*This was an interdisciplinary, multi-institute study on ASF virus that linked epidemiological research incorporating participatory approaches that had an action learning component, modern diagnostics and molecular techniques for viral research with mathematical modeling of disease transmission dynamics. The overarching goal was to generate data essential to identifying key intervention points for feasible strategies to mitigate the impact of ASF.

3.2 Description of the Study area

The study was conducted in Busia County in Western Kenya and the adjacent Busia and Tororo districts of Uganda (Figure3.1). Busia County borders Lake Victoria to the South West, the Republic of Uganda to the West, North and North East, and the following Counties; Bungoma and Kakamega to the East, and Siaya to the South East and South. The County falls within the Lake Victoria Basin. The altitude is undulating and rises from about 1,130m above sea level at the shores of Lake Victoria to a maximum of about 1,500m in the Samia and North Teso Hills. The County is the main point of entry between Kenya and Uganda accounting for the bulk of trade between the two countries. The presence of Lake Victoria has allowed the residents of this region to practice fishing as one of the major economic activities in the county. Rainfall is moderate throughout the year allowing the County to experience favourable conditions for crop agriculture. Cassava, millet, sweet potatoes, beans, and maize is grown in small scale. The main economic activity is trade with neighbouring Uganda.

Away from town, the County economy is heavily reliant on fishing and agriculture. Busia district Uganda is located in Eastern region of Uganda, sits across the International border with Kenya; adjacent to its similarly named town of Busia, Kenya. The District borders Tororo District to the north, Busia District, Kenya to the East, the Republic of Tanzania to the south, Namayingo District to the southwest and Bugiri District to the West. Busia Uganda lies approximately 202 kilometres by road, East of Kampala, the capital of Uganda. Busia, Uganda, together with its sister town Busia, Kenya across the border, are busy commercial centres with heavy commercial traffic in both directions. In 2005, Busia was the busiest border crossing between the two neighbouring member countries of the East African Community. This location lies adjacent to the International border. Tororo District is located in Eastern Uganda and it is bordered by Mbale District to the North, Manafwa District to the northeast, the Republic of Kenya to the East, Busia District to the South, Bugiri District to the southwest and Butaleja District to the northwest. Agriculture is the backbone of the district's economy. Most of the district produce is consumed locally or sold in the urban areas within the district. The study region offered a good opportunity for studying the role of social networks in the spread of ASF because most households owned pigs and outbreaks of ASF were frequently reported from this region.The region was considered to be at a high risk of ASF introduction and potential spread because it has a high pig population under the free-range system which would likely enhance ASF virus transmission.

Western Kenya, being on the border with Uganda also offered a lucrative cross-border business that increased the risk of ASF spread between the two countries. This is further complicated by the fact that the pig-keeping households in this border region have homes on both sides of the border and share similar ethnic, cultural and socio-economic backgrounds which could play a role in the spread of ASF along the value chain across both countries.

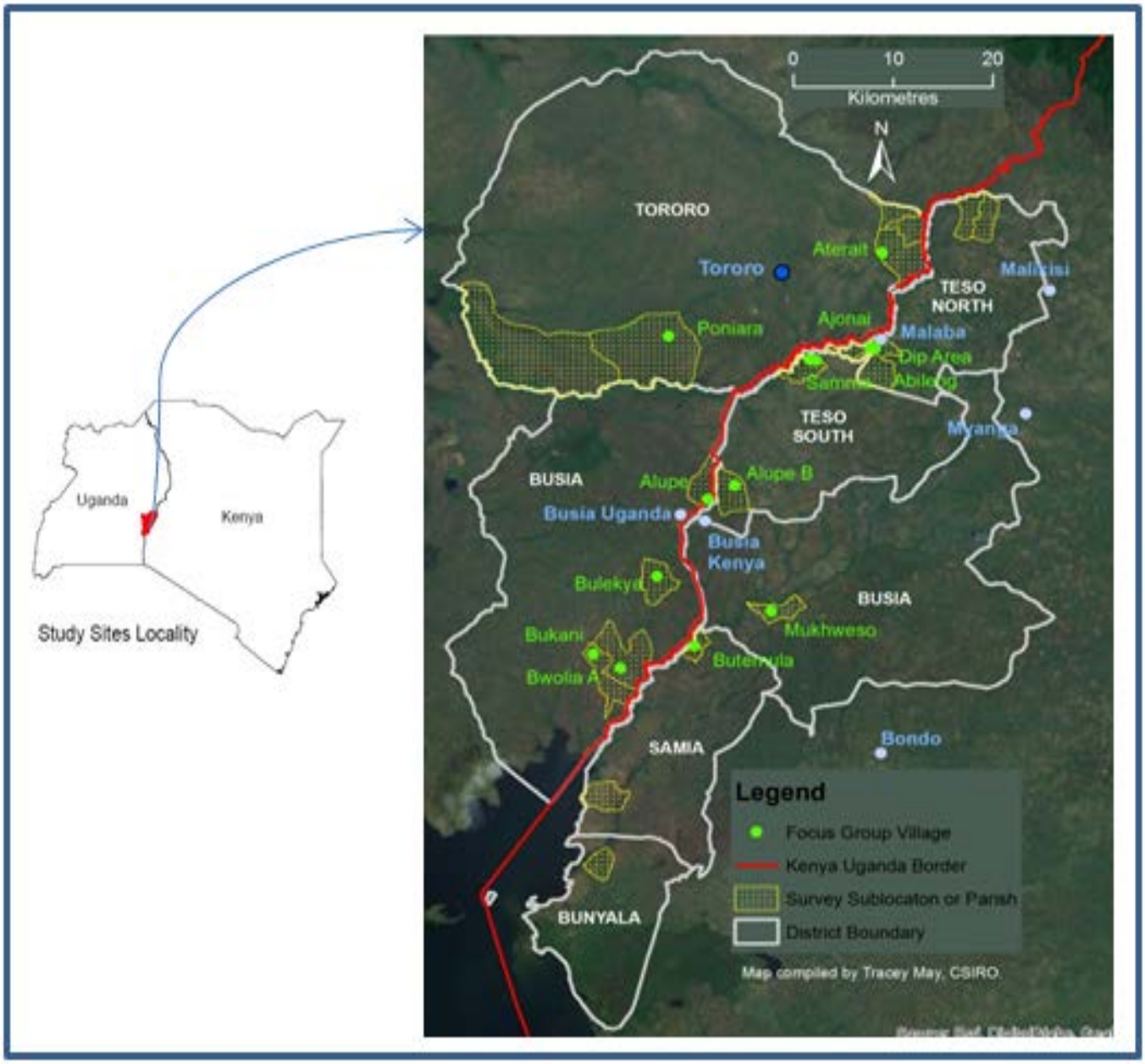

Figure 3.1: A map of the study region (Source; CSIRO, 2012)

3.3 Study design

The study was conducted in two phases; a cross sectional and follow up.

3.3.1 Cross sectional study

There were 683 smallholder pig-keeping households in 38 villages that were interviewed. These were pig-keeping households within Kenya and Uganda to help understand within country and trans-boundary pig movements. Villages were the primary sampling units and households (in selected villages) were the secondary sampling units. Selection of village clusters was by spatial random sampling executed using GIS and the 2008 Kenyan and 2010 Ugandan administrative boundaries. A multi-stage sampling method was used to select 320 households in Kenya and 320 households in Uganda as shown in Figures 3.2 and 3.3 respectively.

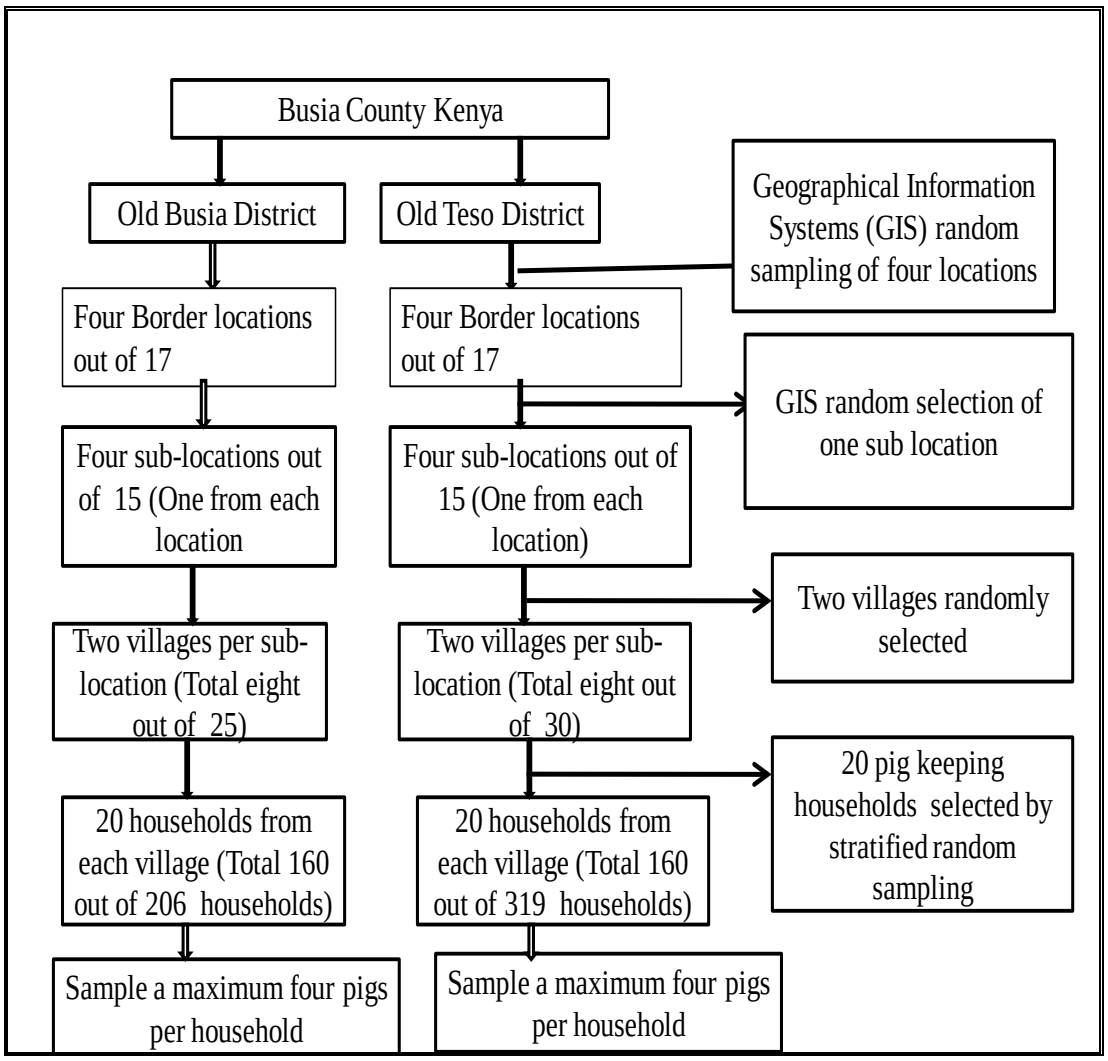

Figure 3.2: Sampling procedure of households in Kenya.

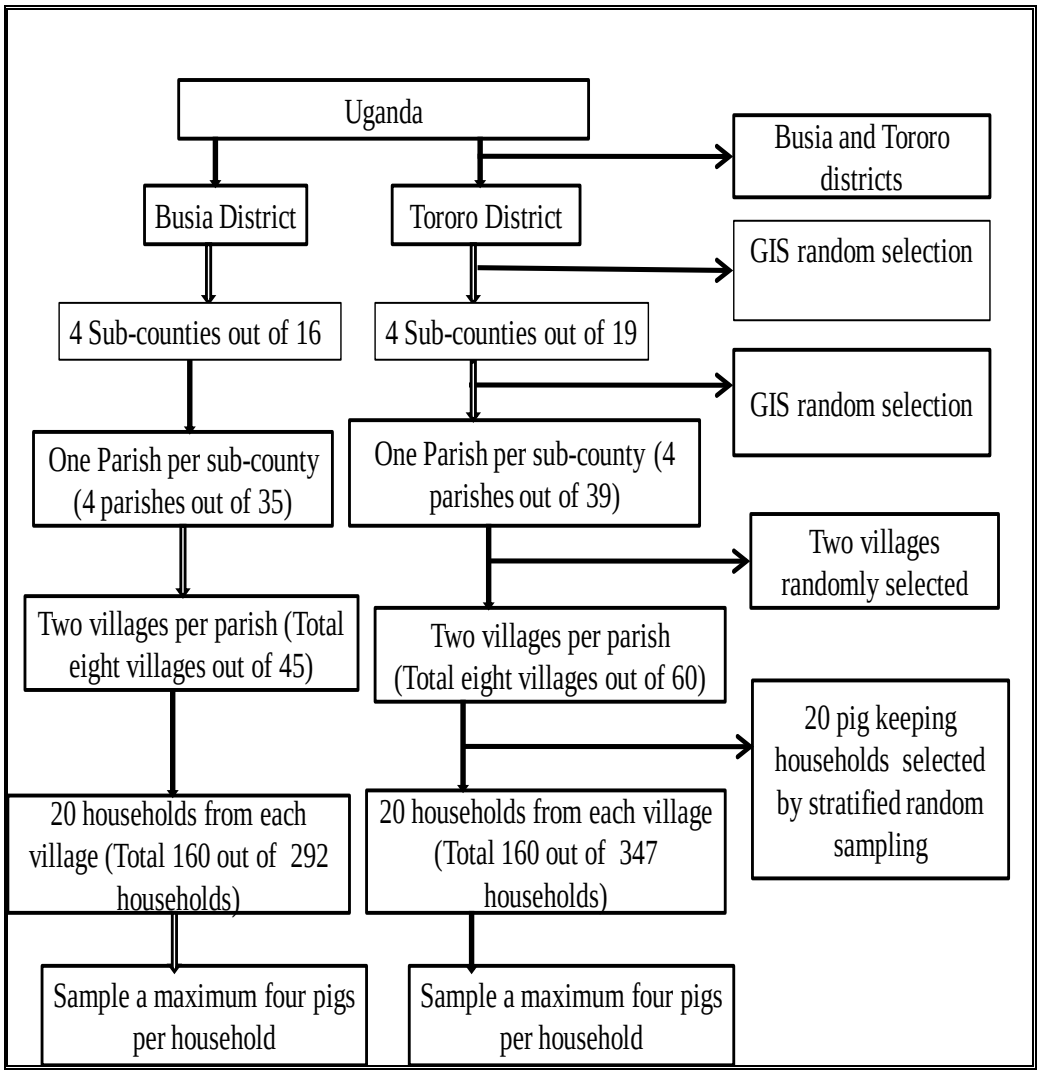

Figure 3.3: Sampling procedure of households in Uganda

Two-stage sampling has been identified as the preferred strategy for assessing prevalence of livestock pathogens where the prevalence variation between herds is greater than that within herd variation, (Farver, 1987). For the selected sub-locations and parishes in both Kenya and Uganda, respectively, information that was not accessible in the public domain was sought from veterinary officials and village leaders. In both study sites, lists of villages in each selected Sub-location or Parish and the numbers of households in villages with their pig-

keeping status was obtained from the village leaders. These lists were used to guide village selection, as described below.

The adopted criterion was that villages had to have at least 20 pig-keeping households to be selected for sampling. In cases where more than two villages with at least 20 pig-keeping households existed, two villages of this size were randomly selected. Smaller villages were randomly selected and the selection was extended to include households from adjoining villages to make up a total of about 20 households across a contiguous area. Thus, in Teso District, Kenya, Atapar and a number of small villages in the vicinity of Dip, Kajei sub-location, were combined into a single component called “Dip Area” for village sampling and analysis purposes, and Erot Ketome and Apokor A in Apokor sub-location were combined to a single component called Erot Ketome/Apokor A. The 32 villages that were randomly sampled and the corresponding administrative levels are shown in Figure 3.4.

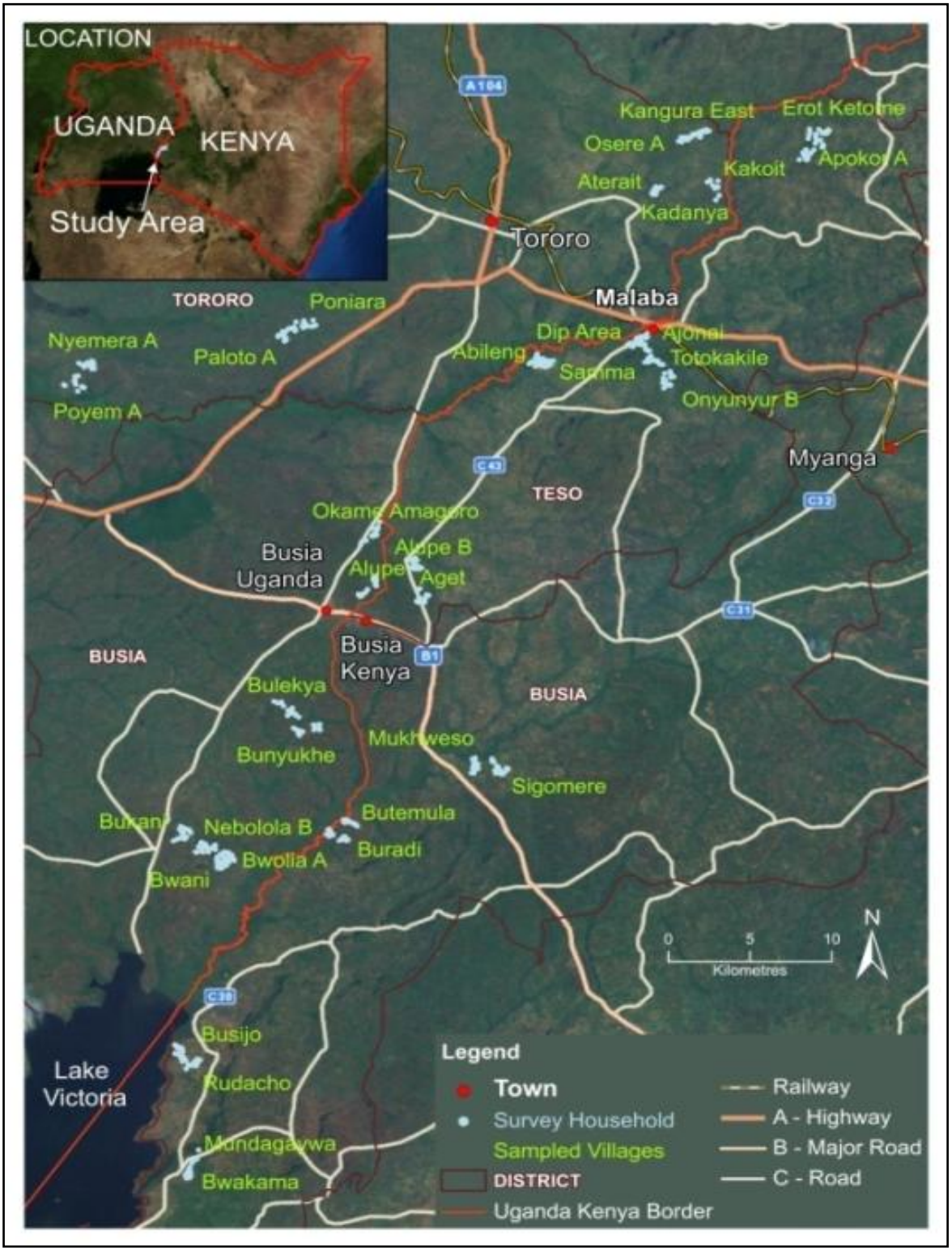

Figure 3.4: A map of the selected villages (Source; CSIRO, 2012)

The cross sectional study and pig sampling procedures described were also applied in two additional villages that were purposively selected because there were reports of ASF outbreaks at the time. These were Totokakile and Onyunyur B villages in Onyunyur sub-location, Busia District, Kenya, that are also included in the study locations mapped on Figure 3.4. Villages were the primary sampling units and up to 20 pig-keeping households and their pigs were randomly sampled within each selected village.

The interviewees in the selected households were informed on the purpose of the visit and what was expected for their participation in the research (Appendix 1). When they agreed to participate they signed a consent form to show their commitment (Appendix 2). Cross sectional study data were collected through administration of questionnaires to household heads or their representatives via personal interviews. The questionnaire was designed to obtain basic data on production, social, economic and marketing characteristics (Appendix3). The cross sectional study questionnaire included general information about households and also served to identify the structure of social networks that households engaged in when trading in pigs, getting advice and help about pig-keeping.

A maximum of 16 ml of blood was collected from the external jugular vein of pigs in the selected households for serum and whole blood. Blood was collected from a maximum of four pigs from each household. All age categories within the household were represented but piglets less than three months, blood was not collected.

3.4 Sample size determination of the cross sectional study

Sample size was guided by Magnani (1997)

$$\boldsymbol{n = [z^2 \times p(1-p)\ /m^2] \times 2}$$

Where n= required sample size,

z = confidence level at 95% (standard value of 1.96),

p = estimated prevalence of ASF in the project area

and

m = margin of error at 5% (standard value of 0.05)

To account for the design effect, the sample size was multiplied by 2. Using an estimated prevalence of ASF 30% based on a study by Okoth *et al*., (2012), a sample size of 645 households was obtained.

3.5 Extended social networks study

Extended social network study was conducted to identify the structure of social networks that farmers engaged in when trading in pigs, obtaining advice and help about pig keeping. Guided by information from cross sectional study with pig farmers, network data were collected from other pig value chain actors. Because this follow-up extended the data set from farmer interviews to encompass other value chain actors in the farmer-centered pig trade networks, it was referred to as the 'extended social network' study and data. Semi-structured interviews were conducted with selected traders and animal health service providers using questionnaires, (Appendices 4 and 5).

During the cross sectional study, the smallholder farmers mentioned 40 traders in Kenya while 35 were mentioned in Uganda by name. Households that had mentioned selling pigs to traders were 153 from Kenya and 90 from Uganda. Of the households that mentioned traders, 100 from Kenya and 41 from Uganda did not know those traders by name. Trader interviews were conducted with 17 traders in Kenya and 16 in Uganda. Two traders were interviewed per sub-location with a bias on those that were mentioned two or more times by different households. On visiting the pork butcheries where the smallholder pig farmers were selling

their pigs, it was not easy to identify who the trader was. They had to first understand the purpose of the visit before revealing their identity. Winning their trust so as to interview and even give full information was a challenge. In this study, the traders doubled up as butcher men/women and therefore the name trader was used to refer to both traders and butcher men/women.

The animal health service providers (AHSP) that were mentioned by households were 54 from Uganda and 52 from Kenya. One Animal Health service provider was interviewed per sub-location. These were the Animal Health service providers that were mentioned by the smallholder farmers two or more times as providing services to them.

3.6 Data analysis

Data was captured using Palm Digital Assistants (PDA) manufactured by Aceeca Limited in Christchurch, New Zealand (http://aceeca.com/about-us). The PDA device was Aceeca Meazura™ MEZ-1000. The Software run on Pendragon forms 5.1 and data was downloaded into a Microsoft Access database on a computer Product URL: http://www.pdsmobilecomputers.co.uk/store/rugged-pda/22-aceeca-meazura-mez-1000.html.

3.7 Research ethics approval

Participation of, and collection of data from people who participated in the project was governed by ethics approval from Commonwealth Scientific Research and Industrial Organization (CSIRO)-Social Science Human Research Ethics Committee (CSSHREC), approval 059/11, (Appendix 6).

CHAPTER FOUR

AN ASSESSMENT OF KNOWLEDGE ABOUT PIG KEEPING AND REPORTS ON AFRICAN SWINE FEVER OUTBREAKS BY FARMERS

4.1 Introduction

All actors in any value chain must be able to recognize and know what measures to take when faced with challenges for example disease outbreaks. Disease recognition enables early detection and improves the effectiveness of any control strategy (Costard *et al.,* 2009b). In this regard, understanding what pig value chain actors knew about pig keeping and diseases affecting pigs is important for the pig enterprise development. The objective of this chapter was therefore to find out the pig keeping knowledge, knowledge/experience about ASF by pig value chain actors (smallholder pig farmers, traders and animal health service providers) in Busia County Kenya, and Busia and Tororo districts of Uganda.

4.2 Materials and Methods

The materials and methods of this chapter are as described in Chapter three. Trends in availability of pigs were sketched using Vensim personal learning edition simulation software version 6.3. Data on reasons for pig sales, knowledge about ASF, sources of pigs by traders and challenges encountered by pig value chain actors was exported to Microsoft excel and analysed using descriptive statistics. The whole blood samples were screened for ASF antigen using Real time PCR (Zsak *et al*., 2005) and Conventional PCR (SOP/CISA/ASF/PCR/1/2009). The serum samples were screened for ASF virus antibodies using ELISA (SOP/CISA/ASF/ELISA/2/2008).

4.3 Results

4.3.1 Overview of pig enterprise in the study area

The overview was based on generalized results from the cross sectional study, trader and animal health service providers' interviews in order to provide contextual information for subsequent analysis of ASF knowledge, incidence and risk factors.

4.3.1.1 Importance of the pig enterprise in the study region

Smallholder farmers kept pigs in order to realize some of the households' financial obligations. Majority of farmers interviewed kept pigs for cash income, a much smaller proportion for home consumption and as a security/current account. Pigs were considered a current account because when households needed money urgently, they easily sold pigs. The number of pork butcheries outnumbered the beef in the area therefore providing a ready market for pigs. Pigs also served as a savings account or easy investment that assisted households plan ahead for future financial commitments e.g. preparing their farms for planting and paying school fees at the beginning of the school term. Households valued Christmas celebrations and therefore most reared pigs specifically to sell in December. The pigs sold enabled the families buy new clothes and also buy foods that were rarely consumed within the households during the year. Income from pig sales was also used for purchasing other farm animals and farm inputs.

Most households interviewed during the cross sectional study bought piglets when they had as little as KSh 600 (USD 6) which they could not invest in a bank or buy other livestock. Although there was minimal investment in the pig enterprise, pig-keeping was the most preferred mode of investing little cash that could not be banked. In comparison to other livestock; cattle, sheep or goats, buying a pig brought in better returns after a few months

because pigs matured faster and they easily survived by feeding on household food leftovers and scavenging for feed. Pigs reached market weight in approximately 9 months and the households sold at KSh 3000. As noted by one of the service providers, "*Pigs pay; even if they die people still try keeping them. People keep pigs through trial and error. Pigs and chicken are thought to be minor livestock and that's why the industry is not growing at the expected rate"*

The smallholder farmers reported that land size was diminishing in the study area as families subdivided family land to sons thereby reducing the available land for grazing animals. Pigs were the only livestock they could rear on limited space successfully. Pigs also fed on a wide range of feeds and have an excellent feed conversion rate compared to other livestock. Pigs also grew faster and had high fecundity. The increasing pork demands created a ready market as people shunned red meat because of health reasons.

4.3.1.2 Trends in the availability of pigs for slaughter

Throughout the study period, it was observed that the buying and selling of pigs along the Kenya-Uganda border largely depended on several factors including; 1) seasons; (wet, dry, planting, and harvesting seasons); 2) occasions such as opening of schools, Christmas festivities and 3) unforeseen happenings e.g. when there was an ASF outbreak or an urgent need for money in the household. The causal diagram (Figure 4.1) gives a graphical representation of the availability of pigs for the market depending on the three factors.

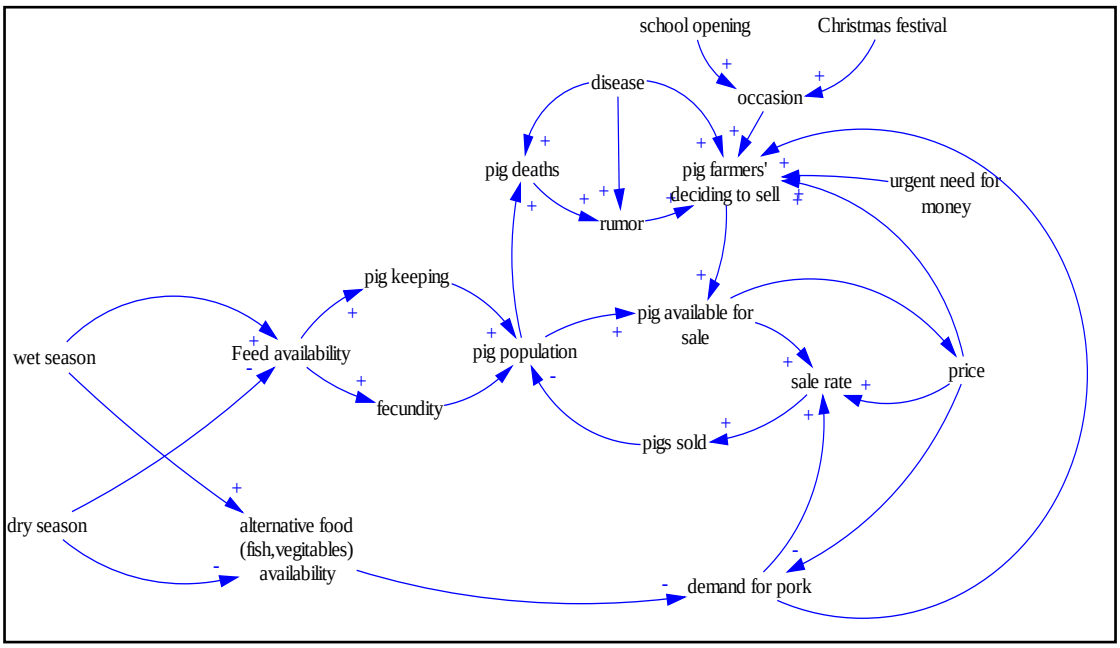

Figure 4.1: Causal Loop Diagram: seasonality of pig availability for market (by Lichoti and Maru)

Vegetables, fish or meat stew are accompaniments for "*Ugali*" (Paste made from maize, cassava, and millet or sorghum flour) that is a staple food for most households in the study region. During the wet months (April to June and October to early December) there was usually food available in households because of the high supply of green vegetables from the farms and abundant fish from Lake Victoria that lowered the demand for pork. Low pork demand meant fewer pigs were slaughtered for home consumption during the wet season thus a high supply of pigs in the market.

In households where the men did not have formal employment, they turned to fishing as a source of income. In the wet months, the men brought fish for the pigs and there were also plenty of green vegetation for the pigs to feed on. The abundance of feed for pigs translated to higher fecundity and faster maturity thus many pigs reached selling weight faster further

increasing the pig population. Availability of more pigs in the market when there is lower pork demand lowered the sale price of pigs.

During the dry months (July to September and Late December to March) the vegetables were less available, the water levels at the lake receded thus fish became scarce. During these periods the pigs were left to roam and scavenge for food for survival. Lack or limited feed for the pigs stunted their growth and they took a longer time to reach market weight compared to the wet season. Households were left with pork as the major accompaniment of *'ugali'*. In the dry months the demand for pork increased because of lack of or limited alternatives such as fish and high priced beef. The high demand for pork increased pig sale price but supply was low because fewer pigs were reaching slaughter weight.

When there were reports of deaths in pigs/rumours of an outbreak of ASF, word spread round so fast and most smallholder farmers sold off their pigs to salvage their investment instead of losing everything to the disease. More pigs were available in the affected area lowering the bargaining power of households. The pig population in the affected area was reduced after disease outbreak or rumour.

At the beginning of a school term or during important occasions such as Christmas festivities, households sold pigs to meet financial obligations. During these times, pigs were available for sale and the sale prices were lower thus decreasing the pig population in households after such occasions.

4.3.1.3 Support among pig keeping households shown through agistment

Pig keeping was valued in the study area such that households assisted one another in pig keeping especially when they did not want to sell their pigs or a household did not have

finances to invest in pigs. This was done through agistment and it was for various reasons. The reasons ranged from labour constraints to disease outbreaks as shown in Table 4.1.

Table 4.1: Reasons households gave pigs for agistment.

Reason for Agistment	Country		Total
	Kenya	**Uganda**	
Labour constraint	30	39	**66**
Feed constraint	26	22	**45**
Space constraint	11	16	**28**
Requested for pig	8	42	**50**
Spread diseases risk	8	7	**15**
Reduce herd size	6	12	**18**
Gift	5	3	**8**
Piglets removed from sow due to over-suckling	4	1	**5**
Lack of market	3	2	**5**
Given to an experienced household	3	19	**22**
Disease outbreak	3	7	**10**
TOTAL	109	171	

In Kenya most households' agisted pigs because of labour constraints (27.5%) while in Uganda most agisted pigs were requested for (24.6%) so that they could also start off the pig-keeping business. When the pig matured, it was sold and the proceeds shared between the households. Some households (2.8% in Kenya and 4.1% in Uganda) agisted pigs during an outbreak of ASF so as not to lose their pigs to disease. Agistment of pigs was also done to assist households who were financially challenged to start the pig-keeping enterprise. If the pig agisted was a sow the recipient took care of it until it farrowed. The owner of the sow took the piglets plus the sow and paid one piglet in return for the service rendered.

4.3.1.4 Reasons for pigs sales in Kenya and Uganda

Various reasons were given on why pigs were sold in 345 households in Kenya and 191 in Uganda. The most common response for both countries was the urgent need for money. This response was given by 51.3% (177/345) of households in Kenya and by 55% (105/191) of households in Uganda. Other reasons for pig sales are shown in Table 4.2.

Table 4.2: Reasons given by households for pig sales in Kenya and Uganda, 2012.

Reason for selling pigs	Number of households per Country	
	Kenya	**Uganda**
Needed money at the time	177	105
Right size of pig for sale	97	29
No response	40	20
Disease or rumour of disease	13	26
Lacked pig feed	12	8
Not specified	4	1
Trader came looking to buy	2	2
TOTAL	345	191

Selling of pigs due to a rumour of a disease or disease outbreak ranked fourth in Kenya and third in Uganda. This practice was likely to enhance disease spread within the region.

4.3.1.5 Sourcing of pigs by traders.

During the study, 17 traders from Kenya and 16 from Uganda were interviewed. Households who wanted to sell pigs either contacted them by phone or visited the butchery as there was no structured market for pigs. Traders visited households that reported to the butchery to assess the health of the pig(s) and bargain for a favourable buying price. Some traders in Uganda reached clients through the local radio FM station or visited a pig market to purchase pigs. The mode of transportation of the pigs from where they were bought from to the

slaughter slabs was by motorcycle, trekking and rarely by motor vehicle. Most of the traders used motorcycle because it could access virtually anywhere within the villages, could carry a heavy load and was affordable.

Traders purchased pigs for slaughter but they also bought them for finishing so that the pigs could gain the desired weight at slaughter (Figure 4.2). Sometimes the traders purchased pregnant sows, which after farrowing they sold off the piglets after a month and slaughtered the sow after fattening. In Kenya, one of the traders at Sio Port sold pigs to Busia town (30 km away), Kisumu (200 km away) and as far as Nairobi (more than 600 Km away) to Farmers' Choice who are the main pork processor supplying supermarket and other outlets in Kenya. Farmers' Choice offered farmers better prices for pigs sold. A Sio Port trader had formed a common interest group with colleagues in the region and they contacted Farmers' Choice after every three months when they had the required number of pigs. Selling to Farmers' Choice was only possible when no outbreaks of ASF had been reported in the area.

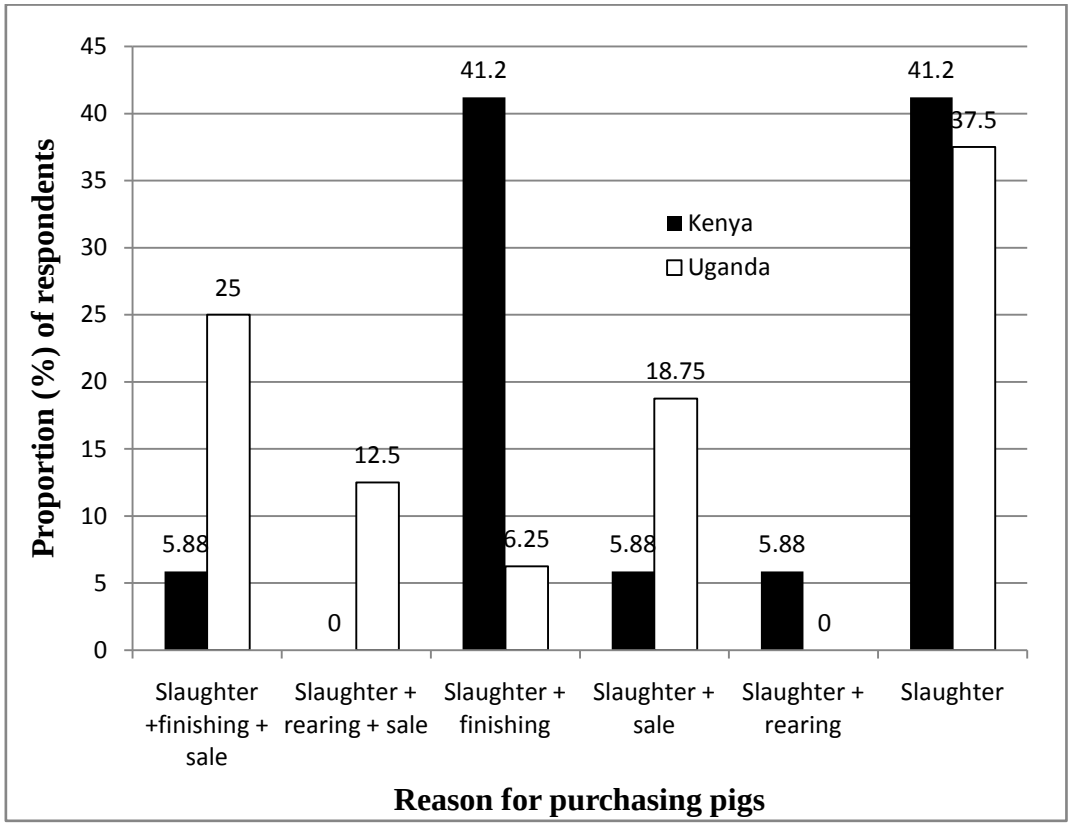

Figure 4.2: Why traders purchased pigs in Kenya and Uganda in 2012

In Kenya 41.2% of the traders bought pigs for slaughter only while 41.2% coupled slaughter with finishing. In Uganda, most traders (37.5%) were buying pigs solely for slaughter while 25% bought them for a combination of slaughter, finishing and sale.

4.3.2 Knowledge about African Swine Fever.

4.3.2.1 Household knowledge about African Swine Fever.

Most of the pig keeping households interviewed knew about ASF disease. In Kenya 81.5% (296/363) and in Uganda 89.1% (285/320) had heard of the disease (Table 4.3).

Table 4.3: Percentage of households with knowledge and those that had experienced ASF outbreaks on farm in Kenya and Uganda in 2012

Country	Responses	Heard of ASF (Percentage)	Experienced ASF on farm (Percentage)
Kenya	Yes	81.5	17.7
	No	15.2	66.5
	No response	3.3	15.8
	TOTAL	**100**	**100**
Uganda	Yes	89.1	23.1
	No	6.3	71.6
	No response	4.7	5.3
	TOTAL	**100**	**100**

Although most households had heard of the disease, only 17.7% and 23.1% from Kenya and Uganda, respectively, had ever experienced ASF outbreaks on their farms. Among the households sampled 11.6% and 16.9% from Kenya and Uganda, respectively, had experienced ASF either in 2011 or 2012. Those that experienced the disease much earlier were 6.4% for Kenya and 6.9% from Uganda. When households learnt about outbreaks, some reportedly sold their pigs earlier than anticipated (7.25%) and some did not restock immediately (12.8%) until there were no more outbreaks or rumours of disease.

4.3.2.2 Trader knowledge of African Swine Fever

All the traders knew about ASF and had come across sick pigs in the course of their business but knowledge about spread varied. The various thoughts by the households on how ASF virus spread is shown in Figure 4.3.

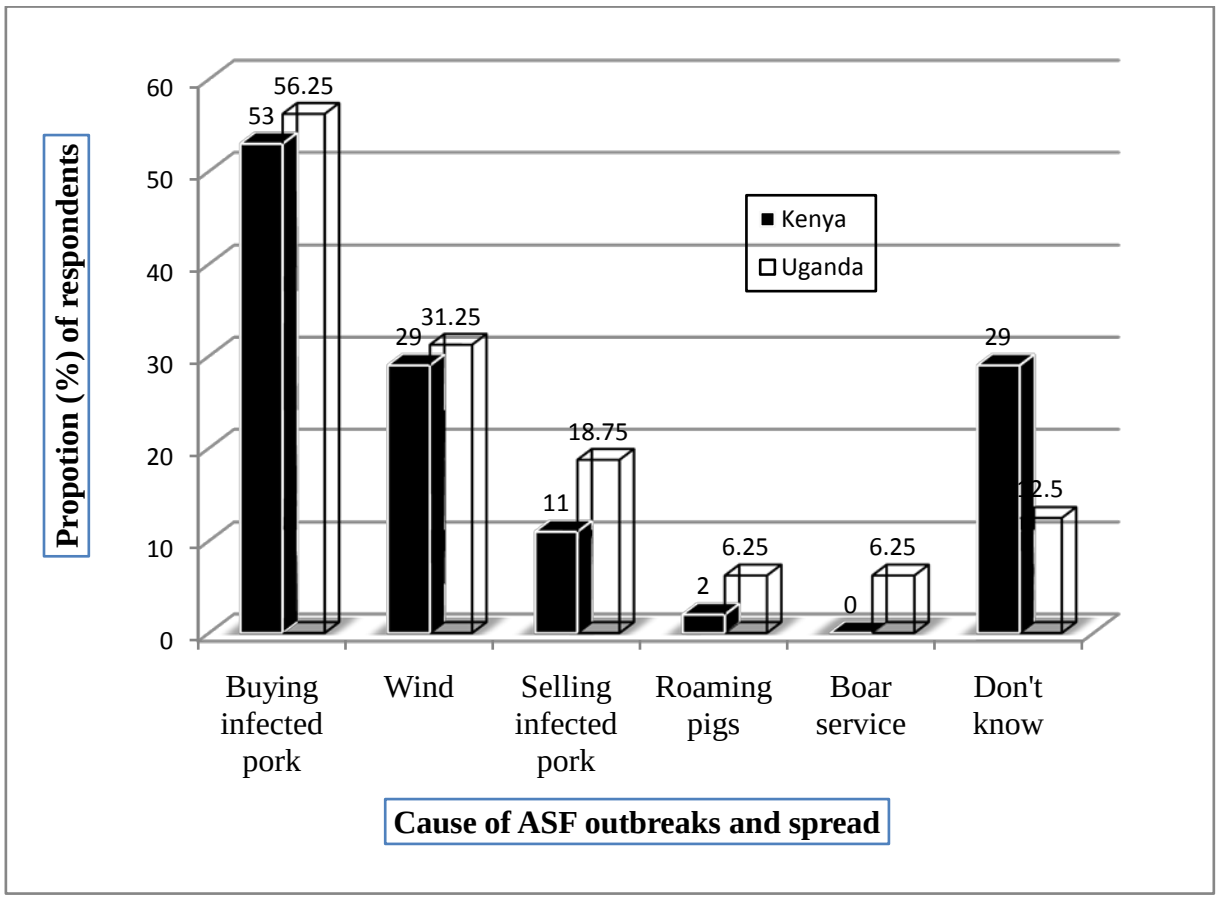

Figure 4.3: Trader knowledge about African Swine Fever spread in Kenya and Uganda in 2012

Among the traders interviewed, 53% (9 out of 17) from Kenyan and 56.3% (9 out of 16)from Uganda cited infected pork bought by households and the household food leftovers containing the infected pork being fed to pigs, as the mode of transmission of ASF virus. Some of the traders 29% (5 out of 17) in Kenya and 31.2% (5 out of 16) in Uganda) thought that since the disease jumped between villages that were far apart, then it must be spread by wind (airborne). Some of the traders, 11.7% (2 out of 17) in Kenya and 18.8% (3 out of 16) in Uganda, actually knew that by selling infected pork, they contributed to the spread of ASF. Most traders were not able to describe the clinical signs of ASF. Out of the 17 and 16 traders interviewed in Kenya and Uganda respectively, 79% from Kenya and 75% from Uganda

respectively, described general sick pig syndrome; dullness, not grunting, innapettance, drooping ears, rough hair coat and coughing. Seven out of the 33 (22%) traders interviewed described clinical signs and lesions in the internal organs after slaughter as skin reddening (petechiations), reddened eyes, change in colour of the internal organs, firm lungs, red spots (petechiations) in the meat, enlarged liver and spleen, edema in chest and tasteless pork. Most of the pork from ASF infected pigs was fried and sold to unsuspecting clients.

4.3.2.3 Animal health service providers' (AHSP) knowledge of African Swine Fever

A total of 14 AHSP were interviewed, eight from Kenya and six from Uganda. Four of the service providers in Kenya did not know how ASF was introduced or spread in the area. Almost all the service providers confessed that they were not competent at diagnosing pig conditions because their qualification and practice had been in treating the larger animals. Indeed during outbreaks some of them tried to treat the sick pigs. In Uganda, one of the service providers mentioned that Buteba Subcounty was near river Malaba where there was a swamp. These areas were prone to ASF outbreaks and they were believed to harbor wild pigs which could play a role in disease outbreaks. In Kenya also, one of the service providers from the Ministry of livestock noted that the number of ASF outbreaks had been reducing since 2007. He attributed this to the clearing of Bunyala swamp for rice farming in Budalangi, Kenya, that started between 2007 and 2009. Clearing of the Bunyala swamp may have relocated the wild pigs when their natural habitat was destroyed. After clearing of the swamp, outbreaks seemed to originate from Uganda and spread to Kenya.

The AHSPs thought that the causes of ASF outbreaks were: the borrowing of a sick boar for service (one had been borrowed from Uganda and it died of ASF sparking off an outbreak in

the area); households buying infected pork and taking it home; roaming pigs; excessive heat and also wind.

4.3.3 Challenges encountered in the pig keeping enterprise

Households faced several challenges when rearing pigs although feed was a major constraint cited by 441 out of the 683 (64.6%) households interviewed. Lack of capital was cited by 93 (13.3%) and pig health by 34 (5%). While feed constraint was a major challenge, the greatest risk to their investment was disease (369 households with 13 specifically mentioning ASF unprompted). Theft was also recorded as a risk and was mentioned by 103 households, while sabotage (poisoning or maiming stray pigs) from neighbours was mentioned by 99 households.

The traders interviewed faced several challenges when carrying out their business. Among the challenges mentioned were loss incurred when; 1)there was nonpayment of pork taken on credit (25% traders mentioned it as the most important challenge), 2) they bought sick pigs unknowingly which died before slaughter, 3) they overestimated pig weight at point of purchase particularly by novice traders, 4) Overnight storage reduced pork weight and decomposition process set in because of lack of cold storage facilities, 5) slaughter slabs were far away from their butcheries and 6) unpredictability of pig business mainly due to disease outbreaks.

When there was an outbreak of ASF, farmers tried to dispose of their pigs and sometimes they sold to traders pigs that were still in the incubation period. The traders only realized later that the pigs were already sick as some died in their custody. When traders purchased pigs from farmers, they estimated the weight based on the length and thickness of the neck region. Inexperienced traders bought pigs at relatively high prices and incurred losses after selling the

pork. Some butcheries, besides selling the raw pork to customers, also sold meals of cooked pork. One of the traders interviewed was using the business to gather enough capital to set up a beef butchery that was more profitable and had fewer challenges.

The animal health service providers faced several challenges in their duty of disease prevention and control. Among the challenges was ignorance of the pig owners about the importance of pigs and therefore poor pig management. Pig owners were not willing to pay for services offered especially if the cost was more than KSh 50 (USD 0.5). The service providers were also not very conversant with pig conditions. Illegal pig movement and trade across Kenya-Uganda border increased the risk of disease transmission. The most important diseases cited included African Swine Fever and others, such as hog cholera, trypanosomosis, erysipelas, pneumonia, dysentery and parasitosis.

4.3.4 Experience of outbreaks of African Swine Fever disease

Outbreaks of ASF were always suspected when there were pig deaths within households. Over 15% and 17% of the households in Kenya and Uganda respectively, lost their pig investment through death, (Table 4.4). Only 78% and 73% of the pigs purchased by the sampled households in Kenya and Uganda respectively, were sold.

Table 4.4: Fate of pigs that were on farm the previous year but were not present at the time of cross sectional study in Kenya and Uganda in 2012

Fate of pigs	Country			
	Kenya		Uganda	
	Number	Percentage	Number	Percentage
Sold	341	78.9	187	73.6
Pig died	68	15.7	45	17.7
Other	8	1.8	0	0
Gift	5	1.2	0	0
Home slaughter	3	0.7	1	0.4
Gift after boar service	3	0.7	1	0.4
No response	4	0.9	20	7.8
TOTAL	**432**		**254**	

Several clinical signs were observed by households that reported death of pigs. Table 4.5 records the clinical signs and the number of households that observed the signs. The clinical signs were recorded starting with the ones that showed probable ASF infection.

Table 4.5: Clinical signs observed by households that reported pig deaths in Kenya and Uganda in 2012

Clinical signs	Number of households mentioning the clinical signs
Sudden death	27
Hyperemia of skin/skin flashing	6
Unsteady gait/swaying gait	12
Shivering	13
Coughing	23
Diarrhea	13
Dullness	39
Lack of appetite	46

Sudden death, hyperemia of the skin, unsteady gait, shivering, diarrhoea and coughing were the clinical signs displayed by a pig infected with ASF virus. Lack of appetite and dullness are general clinical signs of a sick pig.

During the cross sectional study the households were asked when and where they had heard or experienced ASF outbreaks. Appendix 7 records the responses from households in Uganda while Appendix 8 records the responses from households in Kenyan for the years 2011 and 2012. Traders were also requested to name where and when they had seen or heard reports of pigs dying from suspected ASF infection. Appendix 9 records the villages where the traders reported to have seen or heard of ASF outbreaks. These appendices show that there were reports of ASF outbreaks in the region by pig keeping households throughout the year.

The AHSP had a challenge in laboratory confirmation of ASF outbreaks. They relied mostly on the clinical picture of the disease to make a tentative diagnosis prior to the ASF project period. In Kenya, they reported that there had been no laboratory confirmation of ASF

outbreaks except for two that were confirmed by the laboratory set up in Busia during the period of this study. In 2012, outbreaks were reported in 5 villages and in 2 villages in 2013 and the virus spread to several villages.

In Uganda, during the year 2012-2013, 21 outbreaks of ASF were recorded by the interviewed AHSP. Sixteen of these cases were diagnosed based on clinical signs, one was confirmed by laboratory testing and 4 were not confirmed. As in the Kenyan case, original outbreaks spread to several villages.

4.3.5 African Swine Fever seroprevalence and viral infection

The total number of sera collected was 1057. All the samples from the cross sectional study analysed for ASF antibodies using ELISA and DNA using real time and conventional PCR were negative for ASF antibodies and virus

4.4 Discussion

Pig rearing has the potential to raise the income of resource-poor farmers. Sale of pigs provides income for smallholder pig keepers who use the money from pig sales for education, farm preparation and purchase of inputs. The importance of pig keeping by smallholder farmers was also observed by Mutua *et al.,* (2010, 2011a) in a study in western Kenya; Muys and Westenbrink (2004) where pigs were sold to earn family income which was subsequently used to cater for immediate family needs such as school fees and hospital bills. The income used on the farms increased food security within the household. With a pig in the household, smallholder farmers were sure of having a source of money for handling emergencies, as alluded to in other studies, (FAO, 2012; Mutua *et al.*,2011a, 2010; Petrus *et al.*, 2011; Swai and Lyimo, 2014). Apart from selling pigs when finances were needed by households, smallholder farmers also sold pigs when there was a rumour or outbreak of ASF. Selling of

pigs when there was an outbreak of ASF was also observed in Madagascar (Costard *et al.,* 2009b; Randriamparany *et al.,* 2005). Pig keeping has been identified as one of the ways of improving food security and protein intake of the population such that it is being encouraged in Nigeria and Uganda (Nwanta *et al*., 2011; Muhanguzi *et al.,* 2012). Unplanned sale of pigs makes households lose their investment prematurely but also increased the risk of spread of ASF virus. There is potential in pig farming if the industry was treated with the seriousness it deserves. If the potential is exploited, pig production can improve livelihoods and provide affordable source of high quality protein to households, (Penrith *et al.,* 2013).

Starting pig keeping was not expensive and therefore within reach for most households. A household with KSh 600 (USD 6) could buy a piglet and start of pig keeping but such money when banked, would earn minimal or no interest. For the same amount of money, a household would purchase a pig, keep for a maximum period of one year and sell at a minimum of KSh 3000 (UDS30). This was a profit of KSh 2000 (USD 20) considering that the pig was feeding on household food leftovers and grass during this period. This was definitely a hedge against inflation (Petrus *et al.,* 2011) without inclusion of labour and health costs. Households that were financially challenged started pig keeping through agistment. This was a worthy investment and that is why most smallholder farmers gambled with pig-keeping despite the fact that sometimes they lost them to ASF disease. Mutua *et al*., (2010) and Muys and Westenbrink, (2004) also observed that local pig keeping was popular stemming from the fact that, keeping free-range pigs required minimum amount of inputs, and secondly the financial risk involved was small, with little time and money being invested.

Pigs require less space for rearing compared to other livestock making them ideal in the study area because of the diminishing land sizes. Pigs are a livestock of choice in households where

family land has diminished due to subdivision (Mutua *et al.,* 2010). Pigs also produce meat (pork) without contributing to the degradation of grazing lands (FAO, 2011b) and as matter of fact, pig manure is very good in replenishment of farm fertility, (Mutua *et al*., 2010; Muys and Westenbrink, 2004). Pigs are important and their potential has not been realized because of the limited investment in the pig enterprise. Earlier studies by Mutua *et al.,* (2010) recorded limited investment in pig farming by smallholder farmers. Subsistence level pig production is more profitable owing to the higher sale price compared to production costs (Verhulst ,1993).

There were many households that were new entrants in the pig keeping enterprise indicating that although a rewarding enterprise, some households gave up rearing of pigs along the way as new ones got into the enterprise an indication of how dynamic pig keeping was. Dynamism was also observed in western Kenya (Mutua *et al.,* 2011b), where farmers were in and out of pig farming depending on time of the year and season. African swine fever has been implicated in creating fear of pig keeping (Penrith *et al.,* 2013) though farmers keep on trying. The discontinuous nature of pig keeping, and the new households coming in, may contribute to ASF risk because people did not have knowledge based on experience with past outbreaks.

The demand for pork was high as witnessed from the high numbers of pig butcheries in the study area. The demand was reported to be high especially during the dry months of the year when there were no vegetables on the farms and reduced fishing in Lake Victoria. The demand for pork in western Kenya has been recorded to be growing at a rate of 7.4% (Kagira *et al*., 2010a). The increase in the demand for pork in the region has also been reported by Danilo, (2013); Okoth (2012) and Mutua *et al.,* (2010) owing to the lower pork price and availability compared to other livestock. Pork is also a very important source of protein for households compared to beef (Okoth, 2012; www.pigfarmers.co.ug). The service providers

alluded to the fact that pigs were good for the area and if policy makers would consider pig production important and give it priority, then many households would actually benefit.

During the rainy seasons, there was feed for pigs and therefore an increase in pig numbers just as recorded in Zimbabwe (Chiduwa *et al.,* 2008). Large pig populations or an increase in the number of pigs appear to be a risk factor for ASF (Fasina *et al.,* 2010). A country may experience more outbreaks when there are large pig populations with high contact rates because these populations offer an unending source of naïve pigs to infect so that outbreaks are not self-limiting, potentially resulting in rolling outbreaks that can persist for long periods of time (Penrith *et al.,* 2013). Increased pig numbers and movement occurred during Christmas, beginning of school term and when there was a rumour or outbreak of ASF disease. It is during such increased livestock movement that there was an eminent risk of disease spread. Periods of high pig related activities have been shown to record high prevalence as observed in Nigeria (Fasina *et al.,* 2010), although from ASF reports, ASF outbreaks were reported throughout the year. Disease spread has been associated with livestock movement (Bajardi *et al.,* 2012; Brouwer *et al.,* 2012 and Chen *et al*., 2014) thus the AHSPs would use such information to carry out active surveillance when there was increased pig movement. The veterinary authorities mainly relied on passive surveillance through disease outbreak reporting and the submission of diagnostic specimens to the national reference laboratories (Okoth, 2012). It would be prudent that intensification of surveillance during times of increased pig movement (targeted surveillance) be carried out to assist in early detection and control of ASF outbreaks (Rautureau *et al*., 2012). Targeted surveillance will allow for early disease detection and prompt disease control in case outbreaks occurred. Although veterinarians may have access to a large amount of sociological knowledge at the local scale that could be valuable in disease control, it was hardly used during disease control.

Households that reared pigs supported one another to start pig keeping when they were not financially able to buy a pig or when they were not able to sustain their pigs. Assistance was through agistment and this indicated the strength of unity among the pig keeping households in the study area. Agistment of pigs had also been published in earlier studies (Mutua *et al.,* 2011b). The only disadvantage was when they agisted pigs during suspected or reported outbreak of ASF. Agistment during this time only played to facilitate the spread of ASF if the pigs were sick.

There was no organized marketing system for pigs in the study area. The smallholder farmer would look for a trader or the trader moved to households to look for pigs. Lack of a proper marketing system was also observed in Kakamega (Mutua *et al.,* 2010) and in Uganda (Danilo and Kristina, 2012) left the pig keepers at the mercy of the traders. Formation of support groups would help in information flow and regulate market prices among the pig keepers. With improvement in technology pig keeping households can share information through mobile phones as it is very cheap. The households also did not mention obtaining a movement permit when selling pigs indicative of animal movement without the veterinary authority. Through studies by Mutua (2010), farmers reported not obtaining a movement permit made selling of their pigs easier. In western Kenya work carried out by Mutua *et al.,* (2011a) also showed that traders moved from household to households to look for pigs. Movement of traders in search of pigs was a potential source of spread of ASF virus on shoes during periods of outbreaks. Transportation of pigs using motorcycles or trekking increased the risk of spread of ASF virus from potentially infective pig secretions. Motorcycles were mainly used for transportation from far places, but when pigs were bought from the neighbourhood, they trekked as observed in Nigeria (Ajala and Adehesinwa, 2007). African Swine Fever virus can be spread through infective fomites that come into contact with these

secretions (FAO, 2000). Traders did not only buy pigs for slaughter but also for rearing. This could be a survival tactic of ensuring constant pig supply. They also made more profit when they slaughtered their own pigs because of the low cost of production in the region. The periods when there were no reported outbreaks in the region, households teamed and gathered enough pigs that would be bought by Farmers' Choice that offered better sale prices. Selling to Farmers' Choice has been an incentive for better farming practices (Kagira *et al.,* 2010a; Wabacha *et al.,* 2004). Such partnerships between commercial and smallholder producers can result in rapid progress towards an organized and vertically integrated pig enterprise. A ready a lucrative market would encourage farmers invest in better pig keeping practices just as it happened in Mozambique, close to the capital city of Maputo (Penrith *et al.,* 2007). Although selling to Farmers' Choice offered better prices to farmers, buying pigs from multiple farms and movement of live pigs over distances have the potential to spread ASF (Babalobi *et al.,* 2007; Costard *et al.,* 2009a; Misinzo *et al.,* 2010; Fasina *et al.,* 2010; Etter *et al.,* 2011) because it increases direct or indirect contact between households, increasing the likelihood of introducing disease to farms (Alawneh *et al.,* 2014). Provision of a standard slaughter slab within reach by smallholder farmers will help reduce pig transportation over long distances and therefore lower the risk of spread of ASF.

Most households both in Kenya (81.5%) and Uganda (89.1%) had heard of ASF, an indication of the repeated occurrence of the disease in the area. Knowledge about the exact clinical signs of a pig infected with ASF virus was rare confirming what was observed by Mutua *et al.,* (2010) that most farmers are not able to identify common diseases. Although most households knew about ASF, it is possible they may have been confusing the disease with other pig ailments. The traders also gave the general clinical signs of a sick pig as those representing a pig suffering from ASF. No matter the cause of the sickness, traders and

households believed that when a pig was sick, it would die because they believed it had ASF. Some of the traders described the lesions of the internal organs as signs of ASF, meaning they slaughtered and sold or consumed infected pork. Traders believed that ASF disease was spread by wind because during outbreaks, the disease spread to distant villages. Clinical knowledge of ASF transmission has established that aerosol transmission is unimportant, as it only seems to occur over short distances when pigs are in close contact (www.cfsph.iastate.edu/llCAB, 2010), so distant spread by wind was not feasible in the study area. Although the traders knew that ASF disease can be spread through selling of infected pork, many purchased sick pigs and sold the meat to unsuspecting households. Traders were only looking at the profit margins they got during ASF outbreak periods because the after sales profits were good. Traders also thought that they were helping the farmers who at this time desperately wanted to salvage their pig investment. Selling and buying of infected pigs either knowing or unknowingly has been reported in other studies (Costard *et al.*, 2009b; Randriamparany *et al.*, 2005) and this serves to facilitate the spread of ASF in case of outbreaks.

The ignorance about pig diseases by the AHSP confirmed that they were not very keen on pigs because they rarely attended to pig cases. The AHSP, particularly those competent in pig diseases were rare as observed by Mutua *et al.*, (2010) in Kakamega where it was reported that there were no 'pig doctors'. Some of the service providers were treating ASF infected pigs implying that they were not sure about the disease they were dealing with or simply wanted to make money. This may explain why most pig-keeping households sold sick pigs because they did not have experts to advise them appropriately. Indeed, some of the service providers thought that ASF was caused by excessive heat and spread by wind. The treatment of sick pigs only served to spread ASF as the service providers moved from homestead to

homestead. Animal health service providers tended to concentrate on treating large animals and therefore were not competent in pig ailments (Costard *et al.,* 2009a). Since pig keeping was important in the study area, re-training of the AHSPs in the study region and other pig-keeping regions about pig disease would be the first step in making sure that the people tasked with disease control knew what was expected of them.

There was a reported association between ASF outbreaks and the swamp on Malaba river in Buteba County Uganda. There could be the sylvatic cycle in play within this and is contributing to the maintenance of the ASF virus. So far what maintains ASF virus in pigs in the study area is not clear. The sylvatic cycle has not been reported in the area of study but it is thought to play a role in South-west Kenya and the Ruma National park (Okoth, 2012). In Arusha and Kilimanjaro regions of northern Tanzania (Misinzo *et al.,* 2014) outbreaks in domestic pigs has been linked to genotype X Eastern Africa sylvatic cycle viruses. Experimentally infected bush pigs have been shown to transmit the virus to susceptible domestic pigs in contact (Anderson *et al.,* 1998). The potential for the sylvatic cycle in the study area requires further investigation.

Feed for pigs was a major challenge for households in the study area. The feed challenge may be contributing to the free-range production system in the area (Mutua *et al.,* 2010). Disease was deemed as a major risk to their pigs. Earlier studies have recorded ASF as the highest risk in pig production (Kagira *et al.,* 2010b; Nwanta *et al.,* 2011; Muhanguzi *et al*., 2012 and Petrus *et al*., 2011). Some of the other challenges that traders also mentioned were unpredictability of pig business because of outbreaks of ASF. Traders sometimes purchased sick pigs unknowingly and they sometimes lost their working capital when pigs died in their custody. Purchase of sick pigs knowingly/unknowingly as has been reported in work carried out by FAO, (2011b). Traders incurred losses for lack of refrigeration facilities to assist in

overnight storage of pork that was not sold at the end of a business day. Lack of refrigeration services negatively affected marketing of pork products (Ajala and Adehesinwa, 2007) because of meat spoilage and loss of weight. Traders also incurred losses when they overestimated pig weight when purchasing from farmers. Although there have been efforts to assist traders in weight estimation of live pigs (Mutua 2011b), traders in the study area were not applying the method. Traders or the pig owners lost depending on whether there was overestimation or underestimation of the weight of the live pig as observed by Penrith *et al*., (2013). Awareness creation on the method to traders and pig keeping households is recommended to overcome poor weight estimation.

Although there were many cases of ASF being reported, most were not being confirmed by laboratory diagnosis. The only laboratory confirmations were for cases that were reported during the project period. The others were being confirmed clinically. The confirmation of ASF outbreaks by the clinical picture greatly compromised disease control. It is probable that not all the outbreaks mentioned were due to ASF infection. Data collected from the sampled households, AHSPs and traders about the occurrence of ASF disease showed that there were outbreaks almost throughout the year. Availability of laboratory confirmation was the only way to demystify the notion that every sick pig was infected with ASF virus and so destined to die. The availability of laboratory services for quick diagnosis of ASF would create confidence in the service providers to know when to treat and when not to treat sick pigs. This information would go a long way to build farmer confidence when advised by the AHSP. Early diagnosis (Danilo and Kristina, 2012) that is inclusive of laboratory results is the only way of confirming any disease agent. Lack of laboratory confirmation of outbreaks has greatly hampered the knowledge about pig diseases in the study area. The veterinary authorities were not confident when imposing quarantine or did nothing at all because of lack

of laboratory confirmation of ASF. For the samples that were confirmed during the study the veterinary authorities were able to impose quarantine in time because they were confident of their actions. Accessible and affordable diagnostic services would assist in confirming ASF outbreaks and avoid unnecessary quarantines and losses by households that sell pigs due to rumour of ASF or traders who bought diseased pigs unknowingly. Pen side assays could play an important role in quick diagnosis of ASF (Michaud *et al*., 2007). Laboratory diagnosis is essential for correct diagnosis of the disease, due to the strong similarity of ASF clinical signs and macroscopic lesions with those of other haemorrhagic diseases of pigs (Sánchez-Vizcaíno *et al.,* 2012). Earlier studies had recommended the establishment of an ASF laboratory diagnostic service for the pig producing region (Okoth, 2012).

The laboratory results from the 1057 pig samples collected during the study showed that there was no virus circulation in the blood system and there were no detectable ASF virus antibodies by ELISA and PCR respectively despite the fact that this area is endemic. The presence of antibodies against ASF is always indicative of previous infection, since there is no vaccine that is currently used in the field. Research carried out in Uganda (Atuhaire *et al.,* 2013a) showed seroprevalence of 52.96% and 11.5% by ELISA and PCR respectively in apparently healthy pigs. A study in Southern Malawi gave overall prevalence of 12.4% in 445 pigs sampled in 35 villages (Allaway *et al.,* 1995) while in Nigeria 9% of serum samples and 48% tissue samples were positive for ASF virus antibody and genome respectively (Fasina *et al.,* 2010). The absence of antibodies in the study area could be due to virulence of virus so that infected pigs die, lack of sensitivity of the serological tests recommended by OIE (Cubillos *et al.,* 2013) or specific characteristics of the local breeds of African pigs and not antigenic polymorphism (Gallardo *et al.,* 2013).

CHAPTER FIVE

RISK FACTORS ASSOCIATED WITH AFRICAN SWINE FEVER INFECTION IN BUSIA COUNTY KENYA, BUSIA AND TORORO DISTRICTS OF UGANDA

5.1 Introduction

Understanding what influences the survival of ASF virus on pig farms is a key component in developing a risk-based approach to understanding the epidemiology of ASF and controlling the disease. An ecosystem health approach to disease control (taking into account virus properties, factors that contribute to survival of the virus in the environment and pathways through which virus spreads including human behaviour) is imperative. This chapter explores pig husbandry and trade practices that could be potential risks of ASF virus introduction and spread in the study area.

5.2 Materials and Methods

The results from this chapter are drawn from the materials and methods in chapter 3.

5.2.1 Data analysis

Data was also exported from access to Statistical Package for the Social Sciences (SPSS) version 21.0 and Microsoft Excel for analysis. Statistical analyses of unit data were carried out using descriptive statistics presented as tables and graphs. In addition, data was exported to Microsoft excel for descriptive statistics and inferential analysis performed using GeneStat Discovery Edition 4. Descriptive analysis involved presenting various risk factors as proportions of farms. The risk factors analysed were; pork consumption and frequency of consumption in households, frequency of visitors, treatment of external parasites, pig feeding practices, collection and decomposing of pig faeces. Inferential analysis was done using

logistical regression analysis and the response variable was farmers' knowledge of ASF outbreaks in the household pigs. Explanatory variables are the risk factors explained above. For all analysis, level of significance was 5%.

5.3 Results

5.3.1 Risk factors associated with pig keeping households characteristics

5.3.1.1 Pork consumption in the households

Among the households interviewed, 19.6% (134 interviewees-60 from Kenya and 74 from Uganda) did not consume pork while 79.2% (541 interviewees-297 Kenyans and 244 Ugandans) consumed. Those that consumed pork, (Figure 5.1), did so either sometimes or rarely.

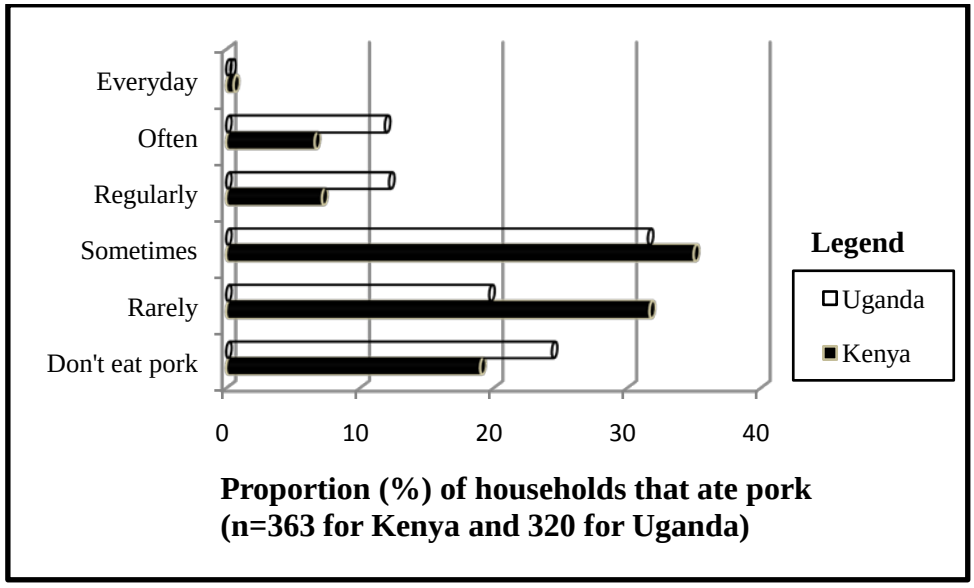

Figure 5.1: Frequency of pork consumption by households

Less than one percent of the households ate pork everyday in Kenya and Uganda.

The risk of consumption of pork as relates to ASF experience was analysed and the association between ASF outbreaks and pork consumption was also determined. Table 5.1

gives the number of households that consumed or did not consume pork and the ASF outbreak.

Table 5.1: Patterns of pork consumption and reported outbreaks of African swine fever (ASF) in the studied households in Kenya and Uganda, 2012

Country	Pork consumption	Reported outbreaks		Total	Rate
		Yes	No		
Kenya	Yes	56	195	251	0.22
	No	8	43	51	0.16
Uganda	Yes	61	171	232	0.26
	No	12	58	70	0.17

In Kenya, the experience of pigs getting infected with ASF when a household was consuming, and not consuming pork was 0.22 and 0.16, respectively; the difference was not significant (χ^2 =1.11, P>0.05). In Uganda, the experience of pigs getting infected with ASF when a household was and was not consuming pork was 0.26 and 0.17, respectively; the difference was also not significant (χ^2 = 2.45, P>0.05). Thus, there was no association between a household consuming pork and outbreak of ASF in the household. Most households believed that ASF was spread through infected pork. The association between how often households consumed pork and farmer-reported ASF outbreaks was calculated, Table 5.2.

Table 5.2: Frequency of pork consumption and reported outbreaks of African swine fever (ASF) in the studied households in Kenya and Uganda, 2012

Country	Pork consumption	Reported outbreaks		Total	Rate
		Yes	No		
Kenya	Regularly/often	16	27	43	0.37
	Rarely	40	168	208	0.19
Uganda	Regularly/often	19	59	78	0.24
	Rarely	44	114	158	0.27

In Kenya, the experience of pigs getting infected with ASF when a household was regularly and rarely consuming pork was 0.37 and 0.19, respectively; the difference was significant ($\chi^2 = 6.6$, $P<0.05$). In Uganda, the experience of pigs getting infected with ASF when a household was regularly and rarely consuming pork was 0.24 and 0.27, respectively; the difference was not significant ($\chi^2 = 0.32$, $P>0.05$). Thus, there was an association between the frequency of pork consumption in a household and reported outbreak of ASF.

Among the households that were rarely consuming pork, some reported that they avoided pork when pigs were in the household because they believed that ASF was spread through infected pork. Since they did not know which pork meat was free from disease, most abstained from consuming. It was only the household heads who would go to pork joints or restaurants (when they wanted to eat pork) during these periods to avoid taking the meat home. Among the households that consumed pork, over 78% from Kenya and 74% from Uganda purchased from butcheries, (Table 5.3).

Table 5.3: Percentage of households obtaining pork from different sources for home consumption in Kenya and Uganda, 2012

Country	Source of pork (Percentage)						
	No response	Restaurant/pork joint	Relative	Neighbour	Home slaughter	Butcher	Total
Kenya	19 % (69)	0.8% (3)	0.5% (2)	0.3% (1)	0.5% (2)	78.8% (286)	100% (363)
Uganda	24% (78)	0.9 (3)	0%	0%	0.3% (1)	74.3% (238)	100% (320)

Preference of butcheries over other sources of pork was reported by the households. Less than one percent of the households got their pork from homes and restaurants.

5.3.1.2 Frequency of visitors to household

Human traffic flow to and from households, was high (Figure 5.2). Over 90% of the households received visitors most of the days. Less than 10% got visitors few times a week and less than one percent rarely got visitors.

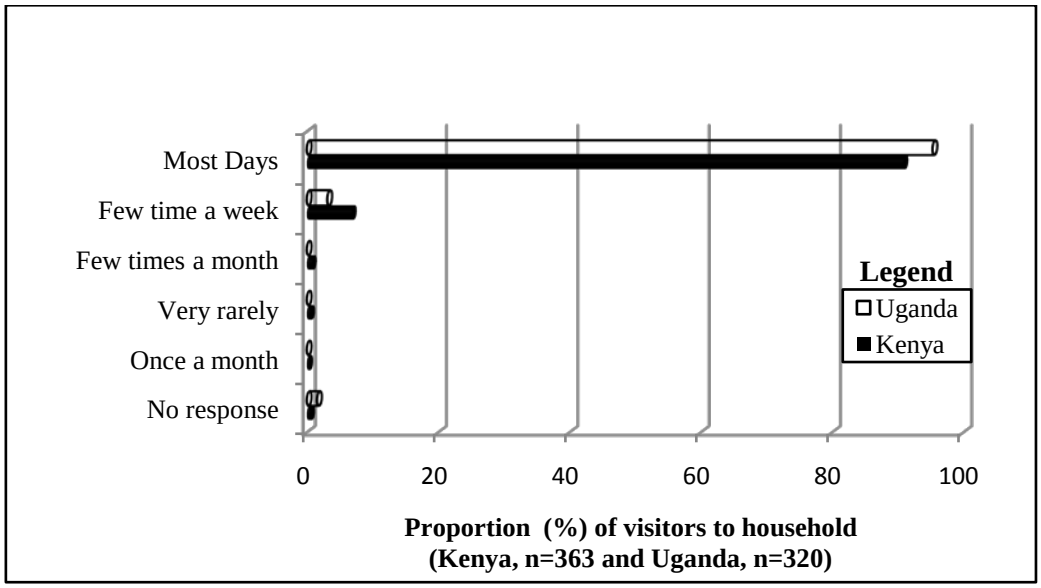

Figure 5.2: Frequency of visitors to the household in Kenya and Uganda, 2012

In the village setup, most households were not completely secluded from the others. There was no significant difference ($P>0.05$) in the experience of reported ASF exposure between households that were frequently and those infrequently visited (Table 5.4).

Table 5.4: Frequency of visitors to households and reports of African swine fever outbreaks in studied households in Kenya and Uganda, 2012

Country	Frequency of visitors to household	Reported outbreaks		Total	Rate
		Yes	No		
Kenya	Frequent	223	61	284	0.79
	Infrequent	15	2	17	0.88
Uganda	Frequent	223	68	291	0.77
	Infrequent	6	5	11	0.55

The experience rate of exposure to ASF of the most visited and less visited household was 0.77 and 0.55 for Uganda and 0.79 and 0.88 for Kenya respectively. Whether a household was visited few or most times, it was equally exposed to ASF outbreaks.

During the interviewing sessions it was observed that most households had paths passing through the homesteads. These paths though not official were shortcuts between households and were the most preferred to the official roads.

5.3.1.3 Association between treatment of pigs for external parasites and ASF outbreaks

Households that treated pigs for external parasites were 63.1% (431 out of 683) while those that did not were 36.9% (252 out of 683). Those that treated their pigs, did it irregularly thus it was common to see pigs with *Hematopinus suis* and nits on the bristles of the pig during the visits to the households. Some households also took their pigs to the river or swampy areas to wallow in mud and they believed that the mud removed external parasites from the pig skin. Table 5.5 shows the association between external parasite treatment and household-reported ASF outbreaks.

Table 5.5: Association between external parasite treatment and reported African swine fever outbreaks in Kenya and Uganda, 2012

Country	Treatment of external parasites	Reported outbreaks		Total	Rate
		Yes	No		
Kenya	Yes	46	156	202	0.23
	No	18	81	99	0.18
Uganda	Yes	47	140	187	0.25
	No	27	88	115	0.23

In Kenya, the experience of pigs getting infected with ASF when treated and not treated for external parasites was 0.23 and 0.18, respectively; ($\chi^2 = 0.84$, $P>0.05$) the difference was not statistically significant. In Uganda, the experience of pigs getting infected with ASF when treated and not treated for external parasites was 0.25 and 0.23, respectively; ($\chi^2 = 0.105$, $P>0.05$) again the difference was not statistically significant. Thus the treatment of external parasites did not have an effect on the household-reported exposure to ASF infection.

5.3.1.4 Association between ASF outbreaks experience and pig feeding practices

Households had varied sources of feed for the pigs reared, probably based on availability. Table 5.6 gives the different sources of feeds for the pigs in relation to ASF outbreaks. In this study swill was defined as external sources of food leftovers e.g., food brought from hotels, institutions or other households. Household food leftovers and swill ranked 1st and 5th respectively among the most common feed used for the pigs. Crop residues from the farm and grass were also fed to pigs especially during the rainy season when there were plenty of green weeds.

Table 5.6: Households reported African swine fever outbreaks and pig feeding practice in Kenya and Uganda, 2012.

Pig feeding practice	Number of households that had not experienced ASF outbreaks		Number of households that had experienced ASF outbreaks	
	Number of households in Kenya	Number of households in Uganda	Number of households in Kenya	Number of households in Uganda
Commercial feeds	4	9	1	4
Home mixed feeds	17	4	6	1
By-products from food processing	11	41	7	14
Brew by-products	23	40	8	16
Swill	70	44	24	10
Purchased maize/flour/*ugali*	127	99	30	33
Crop residues	182	177	47	56
Grass	162	197	44	55
Household food leftovers	219	215	59	69

There were 240 households in Kenya and 229 in Uganda that had never experienced ASF outbreaks on their farms. These households were obtaining pig feed ranging from purchased products to those obtained directly from the farms.

Sixty four and 73 households from Kenya and Uganda respectively had experienced ASF outbreak. Households that reported feeding swill to their pigs were 94 from Kenya and 54 from Uganda. The proportion of households that had never experienced ASF outbreaks and were feeding swill was 29% (70/240) in Kenya and 19% (44/229) in Uganda. The proportion of households that reported an experience of ASF outbreaks and were feeding the pigs on

swill was 37.5% from Kenya and 14% from Uganda. Two households from Kenya that started pig farming in 2010 fed their pigs on untreated swill that always contained pork products but reported that they had never experienced ASF outbreak within the households.

Although some households were feeding their pigs on swill, not all of them had reported ASF outbreaks. Table 5.7 shows the number of households that were/or were not feeding swill and whether they had experienced ASF disease in the household or not.

Table 5.7: Association between household-reported ASF outbreak experience and swill feeding.

Country	Feeding swill	Reported outbreaks		Total	Rate
		Yes	No		
Kenya	**Yes**	24	70	94	0.255
	No	40	170	210	0.19
Uganda	**Yes**	10	44	54	0.185
	No	64	185	248	0.257

In Kenya, the experience of pigs getting infected with ASF when a household was feeding and not feeding swill was 0.255 and 0.19 respectively; ($\chi^2 = 1.64$, $P>0.05$).The difference was not statistically significant. In Uganda, the experience of pigs getting infected with ASF when a household was feeding and not feeding swill was 0.185 and 0.257 respectively; ($\chi^2 = 1.24$, $P>0.05$). Again this difference was not statistically significant. Thus swill feeding did not have an effect on the household-reported exposure to ASF infection. The association between households feeding household food leftovers to pigs and household-reported ASF outbreaks were also explored, Table 5.8.

Table 5.8: Association between household-reported ASF outbreak experience and feeding pigs on household food leftovers.

Country	Feeding household food leftovers	Reported outbreaks		Total	Rate
		Yes	No		
Kenya	**Yes**	59	219	278	0.212
	No	5	21	26	0.19
Uganda	**Yes**	69	215	284	0.242
	No	5	14	19	0.263

In Kenya, the experience of pigs getting infected with ASF when a household was feeding and not feeding household food leftovers was 0.212 and 0.19 respectively; (χ^2 = 0.057, P>0.05) and the difference was not statistically significant. In Uganda, the experience of pigs getting infected with ASF when a household was feeding and not feeding household food leftovers was 0.242 and 0.263 respectively; (χ^2 = 0.039, P>0.05) again the difference was not statistically significant. Thus feeding of pigs to household food leftovers did not have an effect on the household-reported exposure to ASF infection.

There were 8 households (four from each country) that treated swill before giving to pigs although they reported that the swill did not contain pork products. Out of the 8 households that treated swill three had experienced ASF outbreaks.

Only one household from Uganda treated household food leftovers before feeding to pigs. Households that obtained swill from restaurants reportedly did so from those owned by Muslims just to be sure that the food leftovers did not contain any pork products.

5.3.1.5 Sanitary aspects of pig keeping households

Most of the households were not using the pig manure in any way, but a few were using it on their farms. Figure 5.3 represents the responses from the households in the two countries on how they utilized the pig faeces.

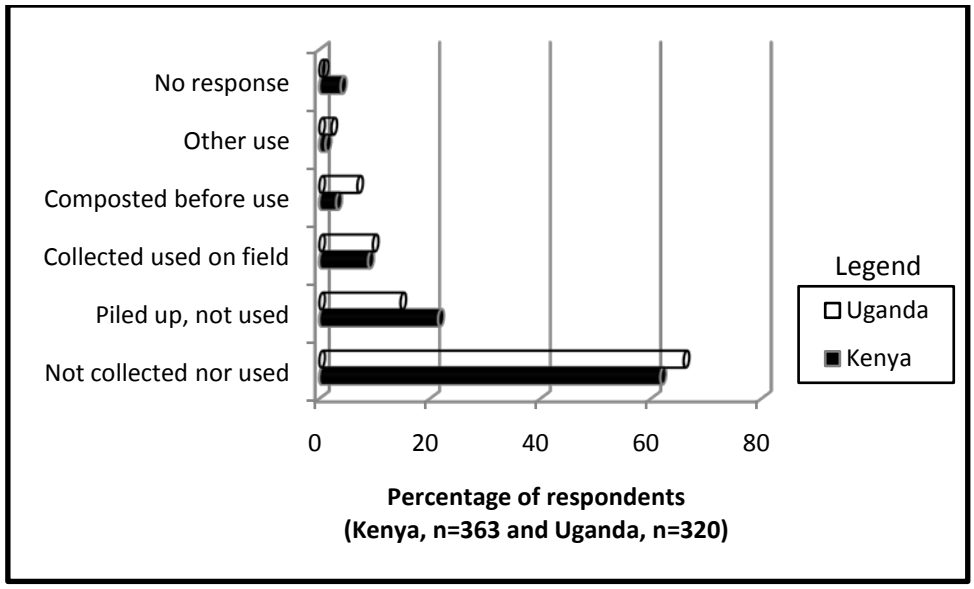

Figure 5.3: Utilization of pig faeces by households in Kenya and Uganda, 2012

In Kenya and Uganda, over 60% of households in Kenya and Uganda neither collected nor used the pig faeces. Less than 10% collected and used it on the farms or composited before use on the farms. Some of respondents did not give an answer to the question probably due to the free range production system that was being practiced and therefore they could not follow-up the pigs to collect the faeces. Most of the households that did not utilize the faeces cited itchiness and cracking of the feet as a reason for touching pig faeces. The association between collection of pig faeces and household-reported ASF outbreaks was also calculated, Table 5.9

Table 5.9: Association between household-reported ASF outbreak experience and collection of pig faeces.

Country	Collecting/disposing pig faeces	Reported outbreaks		Total	Rate
		Yes	No		
Kenya	Yes	14	53	67	0.209
	No	49	184	233	0.21
Uganda	Yes	8	34	42	0.19
	No	67	194	261	0.25

In Kenya, the experience of pigs getting infected with ASF when a household was collecting/disposing and not collecting pig faeces was 0.209 and 0.21 respectively; the difference was not significant (χ^2 = 0.00056, P>0.05). In Uganda, the experience of pigs getting infected with ASF when a household was collecting/disposing and not collecting pig faeces was 0.19 and 0.25 respectively; the difference was not significant (χ^2 = 0.85, P>0.05). Thus, there was no association between collecting and disposing of pig faeces and household-reported ASF infection of pigs.

5.3.1.6 Interaction of African swine fever risk factors

The experience of a pig getting infected with ASF when the risk factors were interacting was calculated, Table 5.10.

Table 5.10: Multivariate analysis of African swine fever risk factors

Interacting risk factors	Country risk and χ^2			
	Uganda		**Kenya**	
	Risk	**χ^2**	**Risk**	**χ^2**
Feeding household food leftover and consuming pork	0.13	2.05	0.21	0.747
Consuming pork without feeding pigs on household food leftovers	1.49		1.33	
Frequent visits and disposal of pig faeces	0.11	2.07	1.46	1.09
Infrequent visits and disposal of pig faeces	1.75		1.67	
Feeding household food leftover and obtaining pork from butchery	0.08	3.67	1.36	8.56
Feeding household food leftovers and obtaining pork from other sources	0.83		0.6	
Frequent pork consumption and obtaining pork from butchery	1.41	0.228	1.6	0.18
Infrequent pork consumption and obtaining pork from butchery	2.03		1.2	

The only interaction that was significant was in Kenya when a household was obtaining pork from sources apart from butchery and at the same time feeding household food left overs (χ^2 = 8.56, P< 0.05).

Using logistical regression analysis several factors were analysed for their level of significance in increasing ASF risk to households, Table 5.

Table 5. 11: Regression analysis of African swine fever risk factors

Parameter	estimate	s.e.	t(*)	P-Value.	Odds ratio
Constant	-8.043	0.237	-33.92	<.001	0.0003213
Pork source: home slaughter	0.85	1.01	0.84	0.400	2.337
Pork source: neighbour	-5.2	17.2	-0.30	0.761	0.005302
Pork source (not specified)	0.76	1.01	0.76	0.449	2.145
Pork source: Relative	-5.2	12.2	-0.43	0.667	0.005302
Pork source: restaurant/pork joint	0.946	0.590	1.60	0.109	2.575
Manure disposal, not collected nor used	0.179	0.266	0.67	0.501	1.196
Manure: disposal Yes, collected and used	-0.157	0.426	-0.37	0.713	0.8549
Manure disposal Yes, composted before	0.799	0.365	2.19	0.029	2.224
Manure disposal Yes, (not specified)	1.230	0.554	2.22	0.026	3.423

When households were obtaining pork from restaurant/pork joint, they were likely to experience outbreaks as seen from the marginal significance in Table 5.11. Compositing of manure likely exposed households to ASF outbreaks as seen from the p-values (0.029 and 0.026).

The association between ASF outbreaks in households and the disposal of pig faeces, feed type and pork source was further analysed Table 5.12

Table 5. 12: Significance of pork source, manure disposal and feed type of African Swine Fever

Parameter	Df	Deviance.	Mean deviance	Deviance ratio.	P-values
Pork source	5	4.3	0.87	0.87	0.5
Manure disposal	4	8.7	2.18	2.18	0.06
Feed type	51	43.4	0.85	0.85	0.77

When a household was disposing manure (P=0.06), they were likely to get exposed to ASF outbreaks.

5.3.2 Discontinuous nature of pig keeping

Pig keeping was a very dynamic enterprise with many of the households interviewed being new entrants. The oldest in the pig enterprise started keeping pigs from the 1970s and the youngest were 2012 (Year when the project was implemented). Table 5.13 shows the year when households started keeping pigs.

Table 5.13: The year the interviewed households started pig keeping

Interval in years when households started pig-keeping	Number of pig-keeping Households according to the time they started rearing pigs	
	Kenya	Uganda
1970-1979	7	3
1980-1989	19	20
1990-1999	38	62
2000-2009	138	122
2010-2012	154	111
No response	7	2

The new entrants in the pig keeping enterprise were more compared to the older ones. It was also noted that many of the households kept pigs intermittently. When households sold pigs due to needs within the households, sometimes they stopped keeping pigs when they did not have cash for restocking; when pigs were not available for restocking; when there was no one to take care of the pigs; or after they had sold them due to reports of ASF outbreaks.

5.3.3 Pig enterprise actor behaviour during ASF outbreaks

5.3.3.1 Households behaviour during ASF outbreaks

During outbreaks of ASF, some households sold pigs to avoid losing their investment. Households in 10 out of the 16 villages in Uganda had sold pigs during a disease outbreak period, while 5 households sold their pigs when there was an outbreak on their farm. Two households had sold the pigs to a relative while 10 had sold to a trader in a different village. In Kenya, nine households in six out of the 18 villages reported to have sold pigs during an ASF outbreak season while 2 households sold their pigs when there was an ASF outbreak on the farm. All the pigs were sold to traders from outside the village. There were more

smallholder pig owners in Uganda reporting to have experienced ASF outbreaks within the villages or within households during the sampling period compared to Kenya.

In Uganda, over 80% of the households sold their pigs within 5km when there was no outbreak, while 70% sold their pigs within this distance during an outbreak (Table 5.14).

Table 5.14: Distance (km) households sold pigs during normal and reported ASF outbreak periods in Kenya and Uganda in 2012.

Country	Distance (km)	Percentage selling when there was no disease	Percent selling pigs when there was a reported outbreak of ASF
Uganda	<1	37.4 (61/163)	35.2 (6/17)
	1 - 5	43.5 (71/163)	35.2 (6/17)
	5 - 10	9.2 (15/163)	5.8 (1/17)
	>10	9.2 (15/163)	0
	Unknown distance and trader	**0**	23.5 (4/17)
Kenya	<1	34.4 (101/293)	0
	1 - 5	40 (117/293)	30.8 (4/13)
	5 - 10	6.4 (19/293)	30.8 (4/13)
	>10	18.8 (55/293)	23.1 (3/13)
	Unknown distance and trader	0	15.3 (2/13)

In Uganda 9.2% of the households sold their pigs beyond 10km when there was no outbreak while 5.8 % had sold within this distance when there was an outbreak. During normal sale of pigs, none of the households sold pigs to an unknown person but when there was an outbreak

of ASF, 23.5% reported that they had sold to an unknown person. Three households had experienced an outbreak and had some of their pigs die but they still sold the surviving pig to a trader.

In Kenya none of the households sold pigs within a 1km radius when there was an outbreak of ASF. Forty percent of the households sold pigs within a 1 km to 5km radius when there was no outbreak while 30% sold within this distance during ASF outbreaks. Those households that sold in a radius of between 5 to 10 km during disease free periods were 6% while 30% sold within this distance when there was an outbreak. Households also sold to unknown traders (15.3% of the households) during ASF outbreaks but none of them had sold to this group when there was no disease. Pig-keeping households believed that once pigs got sick they could never recover and that was why they always decided to sell their pigs for slaughter.

5.3.3.2 Trader behaviour during and after ASF outbreaks

Traders learnt about ASF outbreaks from different source: From farmers when called to buy pigs and finding that the pigs for sale were sick; at the slaughter-houses; and from colleagues who came across such cases. During these outbreaks, farmers reported to have sold pigs at extremely low prices and those who did not get market for their pigs resorted to home slaughter and selling the pork to neighbours. Because of the high supply of pigs during this period, there was also mushrooming of new butcheries within the villages by people, who did not normally sell pork but started the business at these times. These new traders bought pigs at very low prices and therefore sold pork cheaper than normal. Consequently, the established butcheries were hard hit and some of them were forced to close business because of lower demand of pork from usual customers.

In Uganda, 56.2% (9/16) of the traders continued with the pork business during ASF outbreaks while 43.8% (7/16) closed, 13 of them cited competition thus low business volume, two mentioned scarcity of pigs while one each mentioned imposition of quarantine and fear of buying an infected pig. The traders that continued doing business reported that they purchased pigs from villages that were free from ASF or from the infected villages but only bought pigs that were not sick. Some of the traders had experienced the impact of quarantine imposition involving movement control restrictions by the authorities. Therefore during the ASF outbreak period they reported that they bought more pig stocks with the hope of continuing to sell pork throughout the movement control period. After ASF outbreak, the disrupted pork business slowly returned to normal although the traders experienced scarcity of pigs and sometimes the ones who had closed lacked capital to start up business. Traders knew that once there was a rumour or an outbreak of ASF, households sold their pigs. Traders believed that once pigs got sick they could never recover and sometimes they went around announcing that there were outbreaks so that they could buy pigs at cheap prices from the farmers.

5.3.3.3 Animal health service providers behaviour during ASF outbreaks

When AHSPs learnt about ASF outbreaks they advised the pig-keeping households to confine their pigs, isolate sick pigs and dispose the dead ones by burying, gave pig owners more information on how to identify a pig that was infected with ASF virus and report to the local veterinary authorities. In addition, they tried to treat the sick pigs, imposed quarantine to control pig movement and stopped slaughter of pigs in the outbreak areas, informed the local authorities and the traders about the outbreak and carried out public awareness about the disease.

The main actions that the AHSP thought would greatly assist in reducing the number of outbreaks included; confinement of pigs, centralization of slaughter slabs, posting service providers to every area, households desisting from purchasing pork during ASF outbreak periods, and collaboration with traders in the control of ASF because traders usually learnt about the outbreaks much earlier.

5.3.4 Pig slaughtering facilities

Slaughter of pigs for consumption took place either at the slaughter slabs, at the household where the pig had been bought or at the backyard of the butcheries/pork joints. In Kenya most of the traders interviewed (88%) reported that they used slaughterhouses/slaughter slabs structures as shown in Plate 5.1, while only 12% were carrying out home slaughter. All the slabs used for slaughter were privately owned by the butcher-men/women individually or communally. Individuals who owned the slaughter slabs donated land and built according to specifications from the veterinary office. The availability of slaughter slabs was a challenge to the pig traders. In the well established urban centers, the defunct town councils. (there new county administrative units) assisted in their management and charged the traders a fee for the use of the slab. In the smaller trading centers within the villages, traders carried out the slaughtering on their own. During the study one slaughter slab had been constructed communally by the traders within the area.

Plate 5.1: Slaughter slabs in Busia Kenya, 2013

In Uganda only one butchery out of 16 (6.3%) slaughtered pigs in a slaughterhouse or slab. Three (18.8%) of them were slaughtering at home while twelve (75%) had a makeshift slaughter site in the backyard of the butcheries as displayed in Plate 5.2.

Plate 5.2: Make shift slaughter slabs in Busia Uganda, 2013

The many slaughter slabs posed a challenge to meat inspection because personnel who carried out inspection could not manage to visit each and every joint. Meat inspection was almost

non-existent in the study area in Uganda. This posed a challenge in regulation of the trade and therefore the experience of ASF introduction and spread. Lack of organization of the slaughtering process had greatly compromised pork inspection. There were a few meat inspectors charged with the responsibility of making sure pork was fit for human consumption. Accessibility to the slaughter slabs was poor and some of the meat inspectors did not have means of transport to these slabs. During the study, traders reported that pork inspection was carried out at the butchery. This meant that no ante mortem inspection of the slaughter pigs was performed and this created a loophole for traders to slaughter sick pigs.

The offals from the pigs were either given to the Karamoja tribesmen for free or sold to Chinese people resident in the area, who considered them a delicacy. If the offals were not sold, they were thrown into pits or in the bush as shown in Plate 5.3 where they were accessible to scavenging animals, e.g. dogs, birds, and sometimes roaming pigs visited these pits and feasted on the offals further increasing the risk of infection.

Plate 5.3: Pig offals disposal pits, 2013

5.3.5 Pork selling facilities

The pork butcheries in Uganda were open raised areas mostly by the road side as shown in the Plate 5.4.

Plate 5.4: Pork Butcheries in different market places in Uganda, 2013

There was neither protection of the pork from external contamination nor protection of the environment from contamination by fluids from the meat. The butcheries were located in market places where there was a lot of human traffic, potentially increasing the risk of ASF transmission. In Kenya the structures used as pork selling joints, Plate 5.5, were enclosures and most were at market centres.

Plate 5.5: Pork Butcheries in different market places in Kenya, 2013

Pork was put on the counter for display. Sometimes the personnel selling pork had a protective apron to prevent soiling of street clothes.

5.4 Discussion

Pork consumption by households was not associated with reported ASF outbreaks in the study area but there was an association between high frequency pork consumption in the household and experience of ASF outbreaks. African swine fever disease outbreaks are associated with movement of infected pork and pork products (Penrith *et al.*, 2013; Penrith and Vosloo; 2009; DVS, 1994). Households that consumed pork more often were inadvertently likely to purchase infected pork exposing the household pigs to ASF virus when fed on food leftovers. African swine fever virus persists in tissues and the exposure of domestic pigs to insufficiently cooked pork products can result in infection (DVS, 2001; Costard *et al.*, 2009b). The virus can persist for long periods in meat, blood, faeces and bone marrow, (OIE, 2008).

The source of pork in household was a risk to ASF infection and more so, when the source was a restaurant/pork joint. When a household was feeding pigs on household food leftovers and not obtaining pork from the butchery they were likely to experience an ASF outbreak. When there were rumours or outbreaks of ASF there were usually new entrants (mushrooming of pork joints) into the pork selling business taking advantage of the availability of cheap pigs. Pork from these new pork joints was cheaper thus households purchasing were likely to buy infected pork thereby exposing their pigs to ASF virus. Pork that was obtained from other sources apart from butcheries was most likely not inspected especially in Uganda where meat inspection was nonexistent (Danilo and Kristina, 2012). Since the most popular source of pork by households in the study area were butcheries, awareness creation on dangers of obtaining pork from other sources for the remaining few would assist in safe guarding the family pig and control ASF spread.

Information gathered from households revealed no association between swill feeding and households reporting ASF outbreaks. Neither was there any association between reported ASF outbreaks and feeding pigs on household food left overs. Some households reported treating swill before feeding pigs but they had experienced ASF outbreaks. Swill containing pork products has been reported to be a major culprit in the spread of ASF within countries (Misinzo *et al*., 2012, 2014) and across borders (Penrith *et al.,* 2013; DVS, 2001). Swill feeding is discouraged because the ASF virus can persist in tissues and protein environments for long periods of time and the feeding of pigs on swill containing frozen or insufficiently cooked pork products can result in infection (Costard *et al.,* 2009b; OIE, 2008; DVS, 2001). Apart from ASF virus, pig products can be conduits for spread of other diseases e.g. Foot and Mouth Disease (FMD) virus, classical swine fever and swine vesicular disease that have negative economic impact on the livestock industry.

Households frequently received visitors and there were pathways between homesteads indicative of the poor biosecurity measures in place. Pigs were under free range system, (Kagira *et al.,* 2010a; Mutua *et. al.,* 2011a; Okoth, 2012) and were therefore exposed to visitors coming to the households. The current study found no association between frequency of visits to households and exposure to reported ASF outbreaks. Poor farm biosecurity measures (Costard *et al.,* 2009b) have been known to expose pigs to the external environment and therefore increasing the experience of ASF infection. There was no interaction between feeding household food left overs and consuming pork; frequency of visits to household and disposal of pig faeces.

Treatment of external parasites did not have an effect on experience of ASF outbreaks in the current study. Although parasites have been reported as one of the major challenges in pig keeping, households inconsistently treated for external parasites just as was observed by Wabacha *et al.,* (2004) and Kagira *et al.,* (2010b) and therefore not effectively controlling *Ornithodoros moubata*(*O. moubata*), the reservoir of ASF virus (Penrith *et al.,* 2009, 2012). Acaricides have proven to be of little value in controlling *O. moubata* because the ticks spend most of their time off the pigs (Penrith *et al.,* 2013) away from exposed surfaces in dark places (Trape *et al*., 2013). Households taking pigs to swampy areas to remove external parasites by wallowing in mud was also reported by Mutua *et al.,* (2010). Wallowing would play the role of removing those parasites that were resident on the body but not prevent *O. moubata* from feeding because mud has no residual activity. Interaction of pigs from different households in the swampy areas when taken to wallow in mud potentially increased the risk of exposure and spread of ASF (Mutua *et al.,* 2011a). The tick to pig cycle in free range production system is not important in comparison to the pig to pig cycle domestic cycle (Etter *et al.,* 2011).

The results of the study showed that households were neither collecting nor using pig faeces as manure on the farms. Pig rearing was under the free range pig management system that was not ideal for collection of faeces. Households that had an opportunity to collect faeces did not do so because of fear of reported itchiness when the faeces got in contact with their skin. Contrary to this belief, households in Kakamega (Mutua *et al.,* 2010) were using pig faeces as manure on farms because it has been shown to be very good fertilizer (Muys and Westenbrink, 2004). The study showed that collection and composting of faeces was associated with ASF reported outbreaks in households. Studies have shown that ASF virus is hardy and survives in the environment including in faeces (OIE, 2008) where it can be spread on fomites. It is resistant to changes in P^H and temperature over a wide range, as well as to autolysis and various disinfectants (FAO, 2000). Virus is also shed in saliva, tears, nasal secretions, urine, faeces and secretions from the genital tract and contaminated material moved over distances by vehicles and people (FAO, 2000). The free ranging system of pig management may not favour the survival of the virus in the pig faeces for long but composting enables the virus to survive in the environment for longer periods.

When there were rumours or outbreaks of ASF, households in this study resorted to selling their pigs as has been observed in Madagascar (Costard *et al.,* 2009b; Randriamparany *et al.,* 2005; FAO, 2011b) and Nigeria (Babalobi *et al.,* 2007; Fasina *et al.,* 2010). The panic sale of pigs was to try and salvage their investment. Farmers will most likely think of their own interest of selling pigs to get something and hardly of the common good of reporting disease and disposing of sick pigs to control the disease in time. This behaviour of chiefly thinking of own interest and hardly of the common good has been reported by Ostrom (1990). Described as a ‘social dilemma’, it can be overcome by people developing and enforcing shared norms and rules for behavior that complement or work more effectively than rules imposed by

authorities (Ostrom, 1990). In the current pig control Acts in Kenya and Uganda, farmers are not compensated when their pigs die from ASF disease leading to low compliance. Pig owners were more likely to comply with regulations if they received meaningful benefit from regulations (Costard *et al.*, 2009b). Incentives for reporting disease in outbreaks periods would make the farmers comply just as was done in the Krasnodar region of Russian Federation where control measures based on early detection and notification of the disease, promoted by education and importantly, compensation to the farmers enabled control with only the hyperacute–acute form of the disease, without chronic forms of the disease, and an average incubation period of 4.3 days (Sánchez-Vizcaíno, *et al.*,2012). In Mauritius, availing of soft loans to farmers who lost pigs to ASF or culling together with implementation of other control measures helped in ASF control (Penrith *et al.*, 2013). The current measures of imposing quarantine and prohibiting farmers from trading are punitive and therefore not acceptable by most farmers. In Cote d' Ivoire, compensation of a third of farm gate value of pigs during an outbreak made farmers move out some pigs (Penrith *et al.*, 2013) implying that when implemented, compensation should be near or equal to farm gate value for compliance. The established traders lost out on business because new entrants came in to benefit during these periods, creating an unfair competition that had negative effects. To help curb mushrooming of butcheries, the established traders would be advised to form an organization/common interest group that would have membership, regulations for operations in order to block out the ones who took advantage of ASF outbreaks, as stated for Busia Uganda in 2013. Sometimes traders bought infected pigs knowingly or unknowingly and sometimes lost business capital. The losses experienced by traders resulting from deaths of pigs in their custody was a reality in this study and also reported in earlier studies (FAO, 2011b). Continued trade during ASF outbreaks in defiance of regulations facilitated the

spread of the disease in the study area. After panic sale of pigs by households, there was a shortage of pigs just as reported in past studies (Kagira *et al.,* 2010a). Traders who formed trader organizations in Busia Uganda from 2013 reportedly started to collaborate to enforce the trade bans for their own collective good, and also supported those colleagues impacted by the trade and movement bans imposed by the authorities. Developing or empowering pig farmer associations of small groups at local level that can grow into an over-arching national body can have considerable influence and contribute both to the growth of the sector and disease management (Penrith *et al.,* 2013).

Regulation of pig trade in both Kenya and Uganda was minimal if any as was also observed in Uganda (Pezo and Rösel, 2012). Traders were not accountable to anyone and therefore during ASF outbreaks, they bought pigs at very low prices and made profits regardless of the risk of spread of ASF disease. Some even stocked pigs to last them the quarantine period meaning they continued with the trade even when the veterinary authorities had stopped pig slaughter. Stocking of pigs for slaughter during quarantine explains why most traders were not only purchasing pigs for slaughter, but were also rearing pigs. Regulation of pig trade would be effective if they were registered or formed an organization to take care of their interests. An inventory of the traders and mandatory registration of all pig traders by their own organization would encourage accountability to one another and therefore help in controlling outbreaks. Members of a common interest group formulate rules and norms of behaviour that take into consideration the interests of all (Ostrom, 1990, 1992). These groups are able to self-regulate because they are always on the ground and only need external intervention in times of disputes (Ostrom, 1992). External regulation by public/government authorities is inevitable where private interests cannot protect the public domain (Ostrom 1990), therefore registration can be facilitated by the government but the operations should be

left to the members of the organization. Formation of organizations by traders would help in information flow; marketing and access to credit facilities that would boost their businesses as recorded from work carried out in Cameroon (Penrith *et al.*, 2013). Formation of groups or using existing groups to push ASF agenda would help in self regulation. Rewards or sanctions would help traders and farmers change their behaviour of selling and buying infected pigs. Rewards and sanctions do not have to be financial, they can be moral, for example, what would it take for farmers/traders to gain in prestige or influence among their social network for behaving in ways that reduce the disease risk or to be socially ostracized when they do not. There will also be better knowledge, shared norms or group structures that collaborate to reduce risk and the certainty of being caught out if doing the wrong thing.

The AHSPs from this study reported that they specialized in treatment of cattle, sheep, and goat ailments as compared to pigs. The treatment of pigs suspected to be infected with ASF virus facilitated spread of the disease and pointed to a gap in knowledge by the animal health service providers as reported in other studies (Mutua *et al*., 2010). The AHSP when called upon to treat sick pigs did not observe biosecurity measures. They potentially would carry virus particles on their shoes and clothing and facilitate spread of virus to clean households (Fasina *et al.,* 2012; Christley *et al.,* 2003). The lack of knowledge by the animal health service providers was also noted earlier in this study that they were not competent in handling pig ailments.

The places or slabs that were used to slaughter pigs were noted as one of the risks of ASF spread in the study area because they were poor hygienically; sometimes open places where there were no disposal facilities. Pigs were slaughtered under far from adequate conditions in the study area just as observed earlier in Kenya (Kagira *et al.,* 2010a) and Nigeria (Ajala and

Adehesinwa, 2007). In Nigeria, slaughter facilities in the neighbour hood were significantly associated with the risk of pigs being infected with ASF owing to a high level of contamination because infected pigs were often presented for slaughter (Fasina *et al.,* 2012). In Kenya, all the slaughter slabs available were privately owned with a few of the traders carrying out home or butchery site slaughter. The AHSP inspected pork at the slabs but for those slaughtered elsewhere, the inspection was inconsistent. In Uganda, almost all the traders interviewed slaughtered pigs at the backyard of the butchery and thus unsupervised slaughter and no meat inspection in local markets as observed by Pezo and Rösel, (2012); Danilo and Kristina, (2012). Lack of slaughter facilities leads to large numbers of pigs slaughtered without inspection at informal venues (Kagira *et al.,* 2010b; Mutua *et al* 2011a). The offals were thrown in a pit or bush or sometimes sold. Pigs that scavenged in the pits were at a risk of getting infected with ASF virus. Although the Chinese consumed the offals locally, they posed a risk to the pig industry in China because nowadays, people, animals and products travel long distances around the world in very short periods of time. This movement increases the potential for introducing pathogens into new territories (Sánchez-Vizcaíno *et al.,* 2012). Being a DNA virus it survives for as long three months on fomites (OIE, 2008) e.g. shoes and other equipment that it gets in contact with. If these fomites were taken to China during their visits back home, they would be a potential for quick spread once introduced given the density of pigs. The environmental contamination from the slaughter slabs and pits increased the risk of ASF disease spread (Oura, 2013). Majority of pigs in Africa are slaughtered locally without being inspected or recorded (FAO, 2010, 2012; Phiri *et al*., 2003). This is important because the probability of pork that is locally slaughtered and consumed being a direct source of infection for other continents is extremely low, but the likelihood that it plays a role in the maintenance and transmission of ASFV in local pig populations is high. Provision of

slaughter slab infrastructure i.e. standard slaughter slabs and personnel for pig inspection will encourage central slaughtering of pigs. There should also be the enforcement and prohibition of the sale of uninspected meat just as it has been done for beef. Supervision of the slaughter slabs to ensure the regulations are adhered to will help in early detection and prevention of ASF outbreaks.

The pork selling points in Uganda posed a risk of disease spread because they were open structures which were most times situated at the road sides for display and at market places as noted by Pezo and Rösel, (2012); Danilo and Kristina, (2012). People who purchased pork from these butcheries or passed by could easily get in contact with infected fluids from the pork and the virus would spread through fomites (feet and shoes). The virus is shed in large quantities through blood and can be found in all tissues and body fluids, but particularly high levels are found in the blood and massive environmental contamination may result facilitating virus spread on fomites (Oura, 2013;www.cfsph.iastate.edu/llCAB, 2010). The butchery premises were structures that were not biosecure thus posing environmental contamination from fluids from the meat. The insufficient management and control of slaughter slabs and pork selling premises leads to heavy environmental contamination from infective pork fluids which could be a potential source of infection of scavenging pigs (Oura, 2013). Authorization and yearly inspection of butcheries by veterinary authorities will help standardize the structures used for selling pork, ensure safe pork is sold to consumers and control environmental contamination.

CHAPTER SIX

AN ASSESSMENT OF PIG MOVEMENT AND TRADER NETWORKS IN BUSIA KENYA, AND TORORO AND BUSIA IN UGANDA

6.1 Introduction

The spread of ASF has been mostly associated with movement of pigs and pig products which are human activities. There is need to understand social relations among the pig enterprise actors because people and/or organizations are connected by social relations of various types. Social networks have been applied in studying the spread of many livestock infectious diseases that critically depend on the animal movements among premises; so that the data are used to detect, manage and control an outbreak (Bajardi *et al.*, 2012; Brouwer *et al.*, 2012; Chen *et al.*, 2014). The objective of this Chapter was to identify and describe the social networks of pig keeping households, traders and service providers in the study area and their potential contribution towards ASF introduction and spread.

6.2 Materials and Methods

Materials and methods for collection of the data analysed in this chapter are elaborated in chapter three. The data collected that were most pertinent to SNA included the farmer's recollection of the source of pigs that were on the farm at time of survey, both the source and fate of pigs owned during the previous year but no longer present on the farm and the timing and reason of purchase, sale, agistment and boar/sow service events. Interviewees were also asked about the type of social relationship they had with the person from whom they sourced, disposed of, agisted or serviced a pig, their identity, location and distance. Trader data included, village source of pigs, village sale of pigs colleagues in business.

6.2.1 Data analysis

Data were analyzed using the computer packages NodeXL (Hansen and Shneiderman 2009). The graph theory approach (diagramatic representation of direction of relationships) to study pair-wise relationships between objects in the same collection was used (Martı´nez-Lo´pez *et al*., 2009). The sociogram for pig purchases, sales and agistment were drawn by collapsing the households to villages which were considered as a unit or node. The relation between the villages (arcs) was movement of pigs. The trader sociograms were drawn using trader name, villages they sourced pigs from, location of slaughter slab and villages they sold pigs to as nodes. The arcs between them represented movement of trader, pigs or households buying pork. These networks were formed from a clustered sample of households and from a sample of traders that the sampled households sold pigs to.

The density of the networks shows how nodes are connected and it ranges from 0-1. It's the proportion of contacts that could possibly occur compared to those actually observed; higher density means a larger proportion of contacts are observed (Martı´nez-Lo´pez *et al.,* 2009). Modularity compares the expected number of edges within communities to the actual number of edges within communities (Danon *et al.*, 2011). The normal range for modularity is between -0.5 to 1 (Newman 2006). It is positive if the number of edges within groups exceeds the number expected on the basis of chance. The geodesic distance measures the average number of contacts along the shortest path length between all pairs of nodes in the network while the clustering coefficient measures is the sum of proportions of nodes that are directly connected to another node. A value of 1 means every node is directly connected to all other nodes in the network (Martı´nez-Lo´pez *et al.*, 2009).

6.3 Results

6.3.1 Networks for pig purchases by households (source of pigs for rearing)

Households had purchased pigs both from within or neighbouring villages. Figure 6.1 shows a spatial sociogram of villages where the sampled households purchased pigs from. The network represents a description of the set of pig movements with nodes corresponding to villages and arcs referring to pig movements. Clusters were villages that were trading closely with one another. The diagrams show only the arcs (pig movements) between the villages where sampling was undertaken. These partial networks are indicative of the very dense pattern of interconnections formed by pig trading between households and between villages across the study region that characterizes the localized pork value chain.

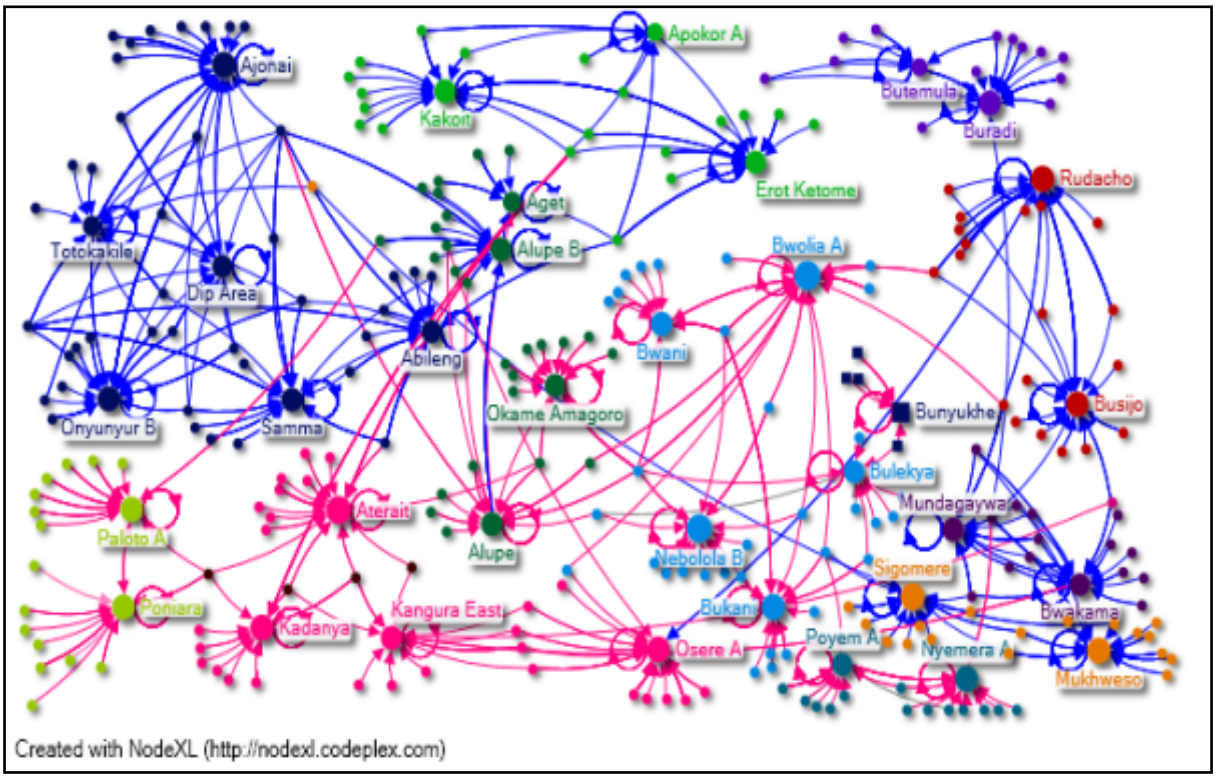

Figure 6.1: Source of pigs in Kenya and Uganda during the 2012 cross sectional study (n=683 households) and the previous year

Key:

1. The blue arcs represent the pig movement in Kenyan villages sampled
2. The pink arcs represent the pig movement in Ugandan villages sampled
3. Nodes represent villages
4. The non labeled nodes represent the other villages where the sampled villages sourced pigs from
5. The self loops/arcs around the sampled villages represent purchase of pigs within the village
6. Similar node colour represent same cluster
7. Arrows show the direction of pig movement

In the villages sampled, there were 12 clusters formed (villages within a cluster have similar vertex color, Figure 6.1). Villages that were adjacent purchased pigs from one another i.e., purchasing of pigs for rearing was dependent on the proximity/location of the villages). The density of the graph was 0.00486 showing that not all the vertices in the graph were connected

to one another. The quality of the clusters (modularity) was 0.234; showing the connections among the villages in a cluster. The shortest path length (average geodesic distance) between villages was 5.56 while the clustering coefficient (how close villages and their neighbours were to forming a complete graph) was 0.049. The average out degree (average number of villages purchasing pigs from same source) was 1.4 with a maximum of 8 and a minimum of one. The number of pigs sourced from the same village was more than those sourced from nearby villages. Although the villages sampled were in Kenya and Uganda, the network was one component, showing that all the villages were connected and therefore; cross-border movement of pigs between the two countries.

The approximate distance (km) covered to places where pigs were purchased is shown in Table 6.1. For both countries, most pigs were purchased from within the village and very few from outside the villages. In Kenya, the majority of the pigs was sourced from within a 5 km radius (93.6%) and in Uganda 83.1% were sourced from the same distance.

Table 6.1: Distance travelled to purchase pigs

Country	**Distance travelled (km)**				
	<1	1-5	5-10	>10	TOTAL
Kenya	386 (57.0%)	248 (36.6%)	17 (2.5%)	26 (3.9%)	**677**
Uganda	232 (47.6%)	173 (35.5)	32 (6.6%)	50 (10.3%)	**487**

Among the sampled households only 3.9% in Kenya and 10.3% in Uganda had purchased pigs beyond a 10 km radius.

A total of 903 pigs in studied in Kenyan households and 719 in Uganda were traded in the period January 2011 to November 2012. Table 6.2 displays the various sources of the pigs.

Table 6.2: Relationship between households that had purchased pigs from one another

Country	Source of pigs								TOTAL
	Neighbour	Other farmer	Family/born in household	Relative	Pig trader	Friend	Self-help group	Non-governmental organization	
Kenya	292 (32.3%)	248 (27.5%)	205 (22.7%)	136 (15.0%)	10 (1.1%)	7 (0.8%)	5 (0.6%)	0	**903**
Uganda	133 (18.5%)	185 (25.7%)	206 (28.7%)	125 (17.4%)	51 (7.1%)	16 (2.2%)	1 (0.1%)	2 (0.3%)	**719**

In Kenya, the major source of pigs was from neighbours, other farmers and pigs born within households. A similar pattern was observed for pigs traded in Uganda (Table 6.2). In Uganda, the major source of pigs was from family (born within households) (28.7%), other farmers (25.7%) and neighbours (18.5%)

6.3.2 Networks for pig sales by households

The villages where households had sold pigs were recorded and illustrated in the network diagram; (Figure 6.2). This shows the movement of pigs between villages through selling by pig keeping households.

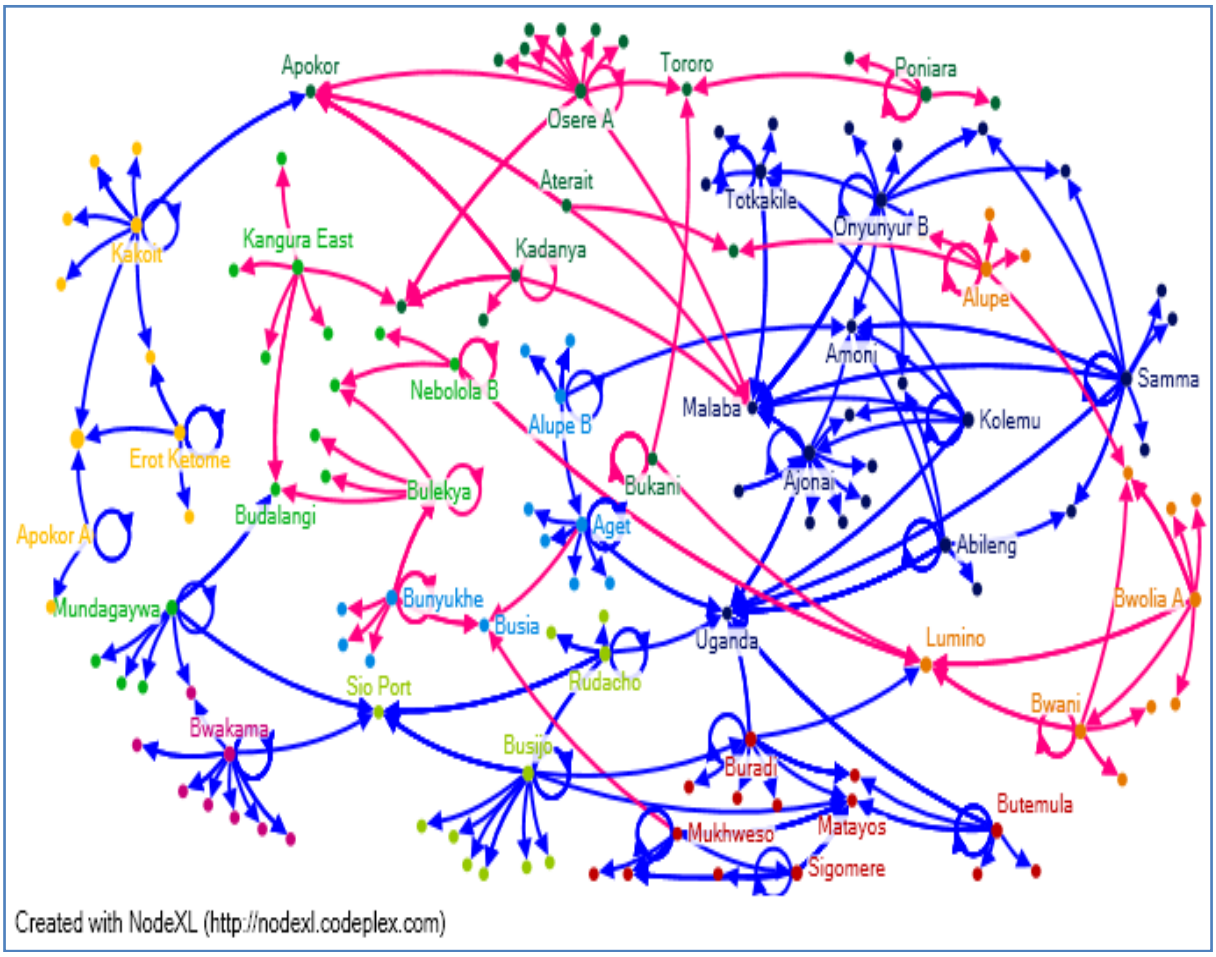

Figure 6.2: Villages where households had sold the pigs they had reared previously

Key:

7.	→	The blue arcs represent the pig movement in Kenyan villages sampled
8.	→	The pink arcs represent the pig movement in Ugandan villages sampled
9.	●	Nodes represent villages
10.		The non labeled nodes represent the other villages where the sampled villages sold pigs
11.	↻	The self loops/arcs around the sampled villages represent sale of pigs within the village
12.		Similar node colour represent same cluster
13.		Arrows show the direction of pig movement

Most households sold pigs within the same village (self loops) or to neighbouring villages. There were 2 clusters of villages that traded more but these clusters joined through at least one common village to form one large network. The average geodesic distance was 4.1; density, 0.009; clustering coefficient, 0.017 and modularity, 0.38. The average in degree (number of villages selling to same source) was 1.5 with a maximum of 19 and minimum of zero. The node Uganda was included because some of the households only knew that they had sold pigs to Uganda but did not remember or know the specific villages. During the period January 2011 to November 2012, 843 and 352 pigs were sold in the studied households in Kenya and Uganda, respectively. The bulk of the pigs in both countries were sold to traders as shown in Table 6.3.

Table 6.3: Destination of pigs sold by studied households in Kenya and Uganda, 2011-2012

Destination of pigs sold	**Number of pigs sold per country**			
	Kenya		**Uganda**	
	Number	Percentage	Number	Percentage
Pig trader	303	35.9	140	39.5
Other farmer	271	32.1	73	20.6
Neighbour	166	19.7	92	26.0
Relative	48	5.7	37	10.5
Other	33	3.9	7	2.0
Unknown	7	0.8	3	0.8
Friend	10	1.2	2	0.6
Local leader	4	0.5	0	0.0
NAADS	1	0.1	0	0
TOTAL	843	100	354	100

One pig from Kenya was sold to NAADS, a Ugandan organization assisting farmers improve their livelihoods through many activities, among them being livestock acquisition.

6.3.3 Networks for pig agistment

Out of households sampled, 10.7% (39) Kenyan households and 19.4% (62) Ugandan households had agisted pigs. At the time of sampling, 10.2% (37) households in Kenya and 26.3% (84) households in Uganda were taking care of agisted pigs. All the sampled villages in Uganda had households that at one time agisted pigs to other household. Figure 6.3 shows the network of villages with households that had agisted pigs.

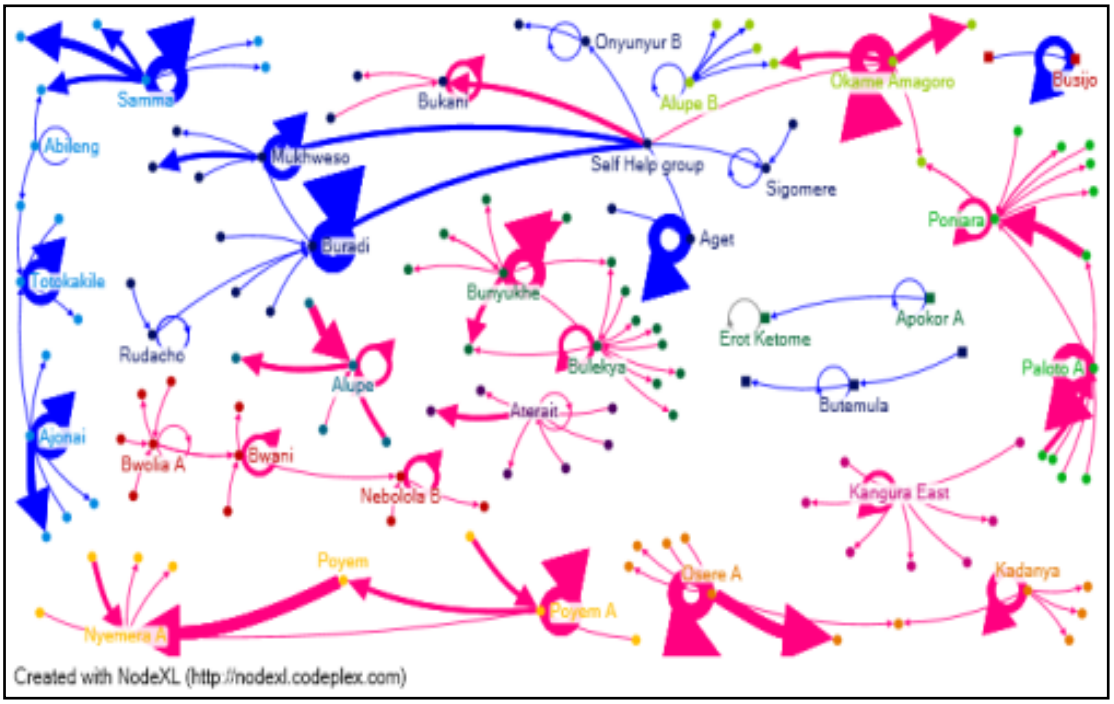

Figure 6.3: Villages in Kenya and Uganda where households had agisted pigs

Key:

1.	The blue arcs represent the pig movement in Kenyan villages sampled
2.	The pink arcs represent the pig movement in Ugandan villages sampled
3.	Nodes represent villages
4.	The non labeled nodes represent the other villages where the sampled villages agisted pigs
5.	The self loops/arcs around the sampled villages represent agisting pigs within the village
6.	Similar node colour represent same cluster
7.	Arrows show the direction of pig movement
8.	Thickness of arrows show the number of pigs agisted

There were 16 components formed in the agistment network. The average geodesic distance was 3.4 and the clustering coefficient 0.033. Households most commonly agisted pigs within the village (self loops in Figure 6.3). The estimated distance between households' agisting pigs is as shown in Table 6.4.

Table 6.4: Distance travelled to agist pigs

Distance (km)	Number of pigs agisted from each country				
	Kenya		**Uganda**		
	Number	**Percentage**	**Number**	**Percentage**	**Totals**
<1	53	48.6	78	45.6	**131**
1 - 5	42	38.5	69	40.4	**111**
5 - 10	5	4.6	11	6.4	**16**
>10	9	8.3	13	7.6	**22**
TOTAL	**109**	**100**	**171**	**100**	**280**

Among the households that had agisted pigs, 242 out of 280 had done so within a 5 km radius while 38 had agisted beyond.

The relationship between households that were involved in agistment of pigs is shown in Table 6.5. Most households agisted pigs from relatives, friends or neighbours.

Table 6.5: Relationship between the households that agisted pigs in Kenya and Uganda

Relationship	Number of pigs agisted per country				
	Kenya		**Uganda**		**Totals**
	Number	**Percentage**	**Number**	**Percentage**	
Relative	61.0	56.0	110.0	64.3	**171**
Friend	16.0	14.7	36.0	21.1	**52**
Neighbour	20.0	18.3	20.0	11.7	**40**
Other farmer	5.0	4.6	4.0	2.3	**9**
Self help group	7.0	6.4	1.0	0.6	**8**
TOTAL	**109**	**100**	**171**	**100**	**280**

The trend was to agist pigs to relatives and neighbours. Majority of pigs agisted in both Kenya and Uganda were weaners- 41.8% (23/55) and 62.4% (53/85) in Kenya and Uganda, respectively. Other categories of pigs agisted but on a lower scale were sows and piglets. Boars were least agisted with only 5 boars agisted in Kenya and none in Uganda.

6.3.4 Sources of breeding boars

A huge proportion of the studied households did not own boars; 91.6% (208/227) and 93.4% (199/212) of the households in Kenya and Uganda respectively either borrowed boars or their sows were reportedly serviced by an unknown free-ranging boar. Only a few households in Kenya (8.4%; 19/227) and in Uganda (6.6%; 14/212) owned breeding boars. The boar: sow ratio was 1:6 (136/21) in Kenya and 1:7 (115/16) in Uganda. The majority of boars in both countries were of the local breed.

The movement of boars/sows between villages for sow service within the study area (excluding servicing while free-ranging) is shown in Figure 6.4 below.

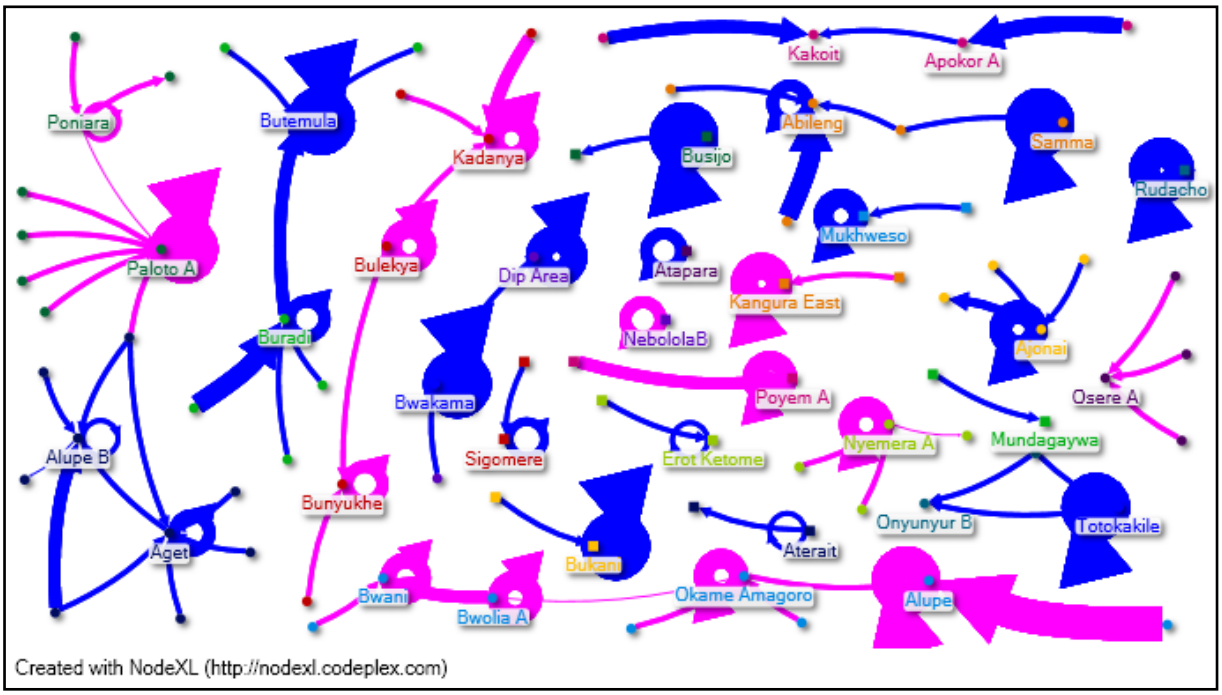

Figure 6.4: Sow Service network and number of sows serviced in Kenya and Uganda

Key:

1.		The blue arcs represent the pig movement in Kenyan villages sampled
2.		The pink arcs represent the pig movement in Ugandan villages sampled
3.		Nodes represent villages
4.		The non labeled nodes represent the non sampled villages as sources
5.		The self loops/arcs around the sampled villages represent servicing of sows within the village
6.		Similar node colour represent same cluster
7.		Arrows show the direction of pig movement
8.		Thickness of arrows represents the number of sows serviced

There were 23 components in the sow service network. Sow service was within the village (self loops) or villages that were adjacent and thus the network was more disjointed. For the households that had borrowed a boar, the maximum in-degree was 6 indicating the number of sows that were serviced by one boar. When sows needed service, either the boar or sow was moved to the temporary home depending on the agreement between the household owners. The pigs from different households were thus mixed without any biosecurity measures being observed, such as separating pigs that arrive on a farm from resident pigs for the ASF incubation period of 2 weeks. The pig stayed at the temporary agisted home for a minimum of

2 weeks or until service occurred. After service the boar or sow was returned to the respective households. Payment of sow service to the boar owner was a piglet after farrowing.

6.3.5 Trader networks

The pig traders interviewed in the study area also doubled up as butchers. A total of 17 and 16 traders were interviewed in Kenya and Uganda respectively. Their ages ranged from 20 to 55 years with the majority in the 30-39 years age bracket; 43.8% (7) in Uganda and 64.7% (11) in Kenya. Most of the traders in both countries had attained a primary level education; 75% (12) in Uganda and 82.3% (14) in Kenya. Only 12.5% (2) of the traders from Uganda and 11.8% (2) from Kenya had reportedly attained a secondary level of education. Most of the traders in both Kenya 41.2% (7) and in Uganda 56.3% (9) had been in pig trade for not more than 5 years at the time of study.

The areas of operation of the traders were not defined. The traders purchased pigs from farmers mainly by visiting households and sometimes in response to a household contacting the trader. Movement by traders to villages would not automatically guarantee getting the pigs in the first household visited. They assessed the pigs and agreed on the buying price with the pig owners before purchase. Sometimes they moved through several households before they got the pigs. The pigs were then transported by motorcycle or bicycle or trekked depending on how far the household was from the butchery or slaughter slab. Figure 6.5 shows the trader movement network according to the villages they purchased pigs from, both for the interviewed (33 traders from Kenya and Uganda) and those traders mentioned by the interviewed traders.

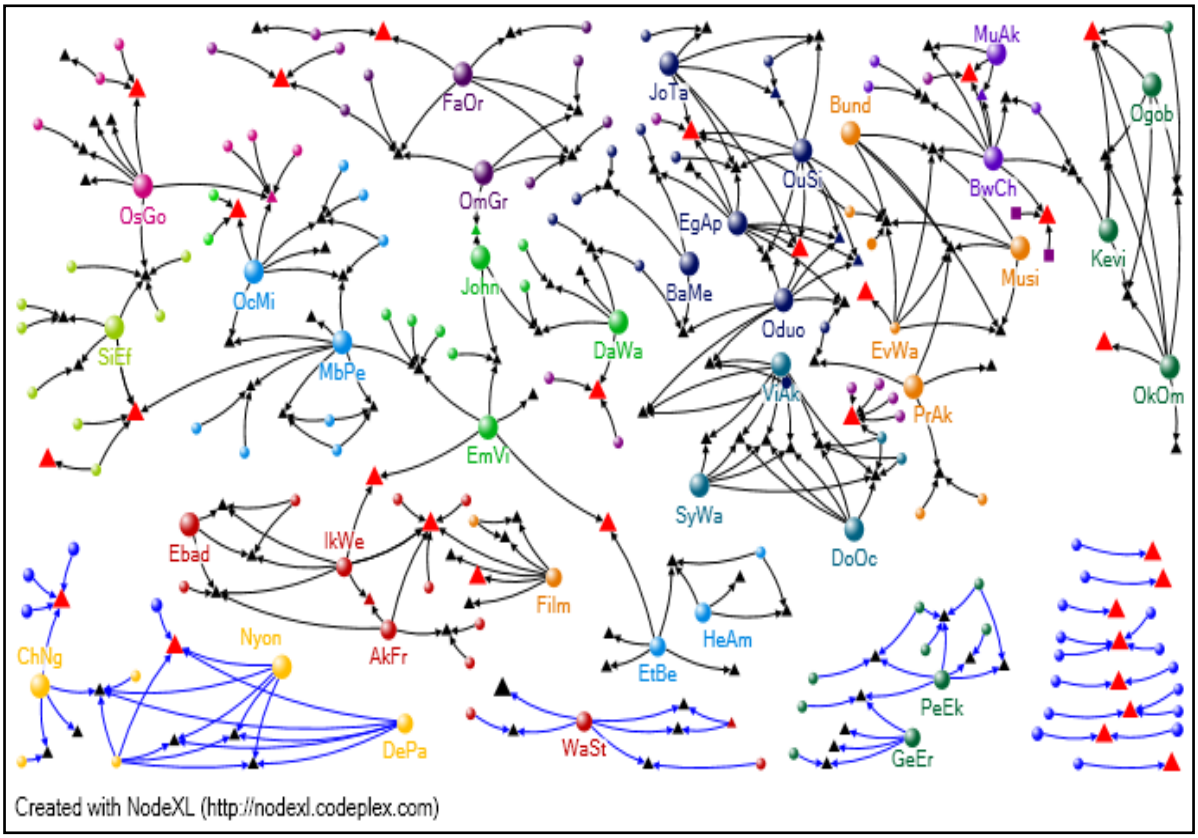

Figure 6.5: Villages that were sources of pigs for traders in Kenya and Uganda, 2012

Key:

△	The triangular nodes represent villages visited by traders to purchase pigs including the villages where the traders were mentioned in the cross sectional study
●	The sphere nodes represent the traders. Vertex name are trader initials
→	The arcs/arrows represent the traders movement to the villages to purchase pigs
▲	The red coloured triangular nodes represent the sampled villages
▲	The black coloured triangular nodes represent the villages mentioned by the traders
	Same coloured trader nodes represent same trader cluster

There were 16 components formed in the trader network. The maximum out-degree (maximum arrows from a trader) was 12 showing that a trader could purchase pigs from as many as 12 different villages. The average geodesic distance was 11.2, showing the average number of steps a trader moves to interact with the others. The density was 0.004 indicating that only 0.4% of the sampled traders interviewed were purchasing pigs from same villages. The traders' movement network was very dense especially in villages that had shopping

centres. Each of the arcs represents a trader moving to a village. The villages with few arcs were visited less frequently by the traders interviewed. Arcs to a node indicated the traders that bought pigs from those villages. These villages were the major pig sources/hubs for traders in the study region. The villages that had few arcs to them had fewer traders buying pigs from them. Though the traders were from Kenya and Uganda, the components formed composed of villages from both countries indicative of cross border trade.

None of the traders mentioned ever obtaining a movement permit to move pigs from the point of purchase to the slaughter slab even though this is a regulatory requirement but only applies if the movement is between districts. These pigs were transported on motorcycles or trekked across the border without the knowledge of the veterinary authorities. In Uganda, traders only mentioned slaughter fees as the only legal requirement they paid for and this was collected by the local authorities. Twenty nine percent (5out of 17) of the Kenyan traders reported to have obtained pigs from Uganda and they used the porous border to sneak pigs into Kenya without clearance from the veterinary authorities. The pigs were either slaughtered at the butchery site or slaughter slab and the pork sold to villages in the vicinity. Though the network showed movement to one village, in reality the traders traversed through households and sometimes villages to be able to get the pigs.

The estimated distance travelled by the traders from the butchery to the villages where they purchased pigs from was within 5Km radius (76%). Few reported to be purchasing more than 30 km away (3.7%). One trader from Uganda had purchased pigs 100 km away from his butchery.

6.3.5.1 Movement of pigs and pork

There were a total of 12 pig slaughter sites in Kenya. Nine of the sites were privately owned slaughter slabs used by several butcheries while the other three were places where individual

traders slaughtered their pigs mostly behind the butcheries. A network of pig movement from village to slaughter slab then to the villages where the pork was sold is shown in Figure 6.6.

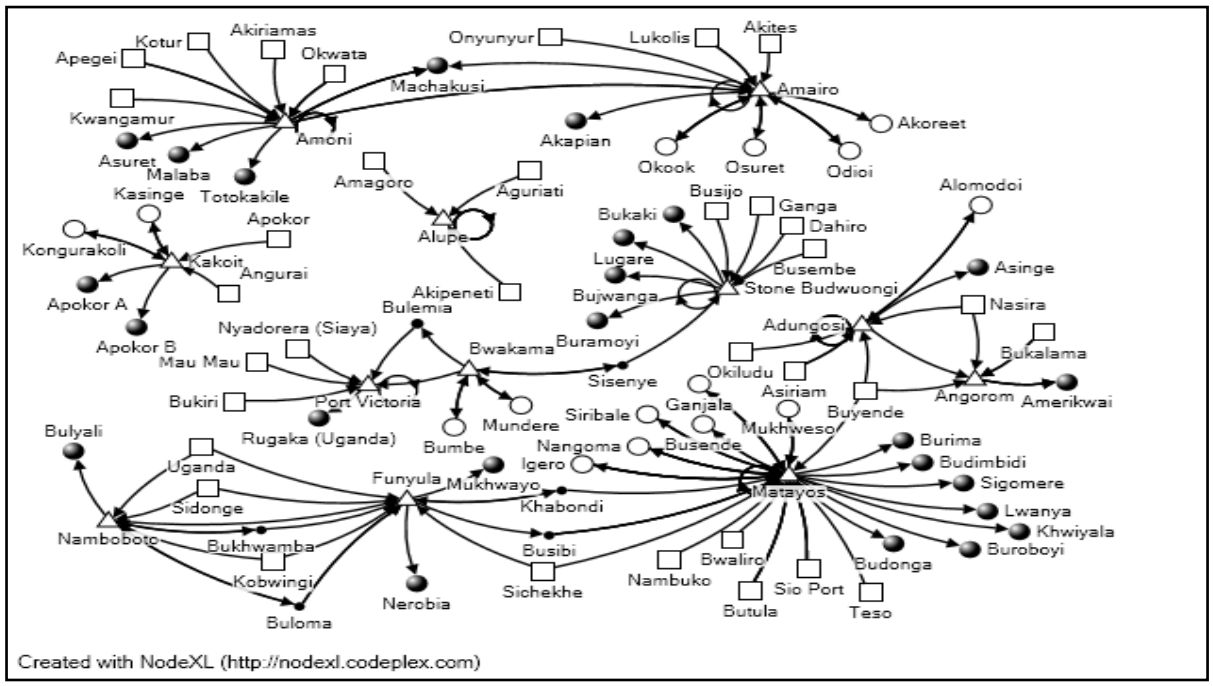

Figure 6.6:A network of pig and pork movement in Kenya, 2013

Key:

□	-The square nodes represent the villages where pigs were sourced from for slaughter	○	-The circle nodes represent villages that are both sources of pigs and market for pork
Δ	-The triangle nodes represent the slaughter slabs		
●	-The sphere nodes represents villages where the pork is sold	→	-The direction of the arrows show the movement of pigs and pork

The nodes represented the villages where pigs were obtained from, taken for slaughter and where the pork was sold. There were five components formed; 3 major and 2 minor ones. Pigs were purchased from different villages and the pork sold to the same or different villages. Three major slaughter slabs in the study area were Matayos, Amoni and Stone Budwuongi. Figure 6.6 shows that pork from a single source could be distributed to many different villages. Distribution generally occurred within a day of slaughter since butchers had no cold storage facilities, so they aimed to sell the whole carcass on the day of slaughter.

In Uganda, every trader slaughtered pigs in the backyard of the butchery, Figure 6.7.

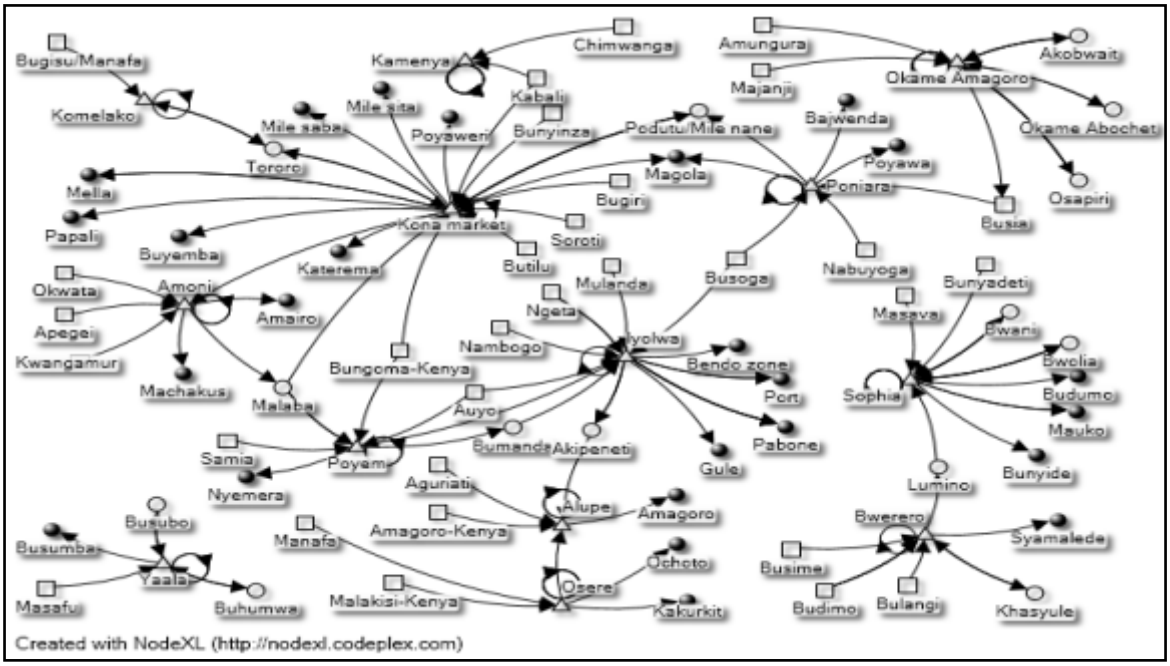

Figure 6.7: Pig and pork movement in Uganda

Key:

□	-The square nodes represent the villages where pigs were sourced from for slaughter	○	-The circle nodes represent villages that are both sources of pigs and market for pork
Δ	-The triangle nodes represent the makeshift/backyard slabs		
●	-The sphere nodes represents villages where the pork is sold	→	-The direction of the arrows show the movement of pigs and pork

Pigs were purchased from different villages and the pork sold to the same or different ones. The sale of pork was widely distributed from a single butchery. In an outbreak situation, if a pig infected with ASF was slaughtered, within the same day infected pork would have been distributed to many villages.

6.4 Discussion

The results showed that sourcing of pigs for rearing by households, slaughter by traders and agistment was localized. Studies have shown that local markets offer a perceived satisfactory market for smallholder farmers where the demand is high (Penrith *et al.,* 2013). The

households interviewed sourced pigs for rearing mostly from the same village. For a household to know where to source pigs for rearing, especially piglets, they needed to get information on whose sow had farrowed. Such information was more readily available within the neighbourhood than from far off villages. Some farmers in the study specialized in producing piglets which were sold to other farmers at the age of one or two months and this has been observed earlier (FAO, 2012). Those farmers then either raised them for slaughter as fatteners or finishers, or raised them for breeding purposes, supplying piglets to other farmers (FAO, 2012) thus making the buying of pigs for rearing localized. Localized movement of pigs in this study was common because farmers did not need a permit to move pigs as reported earlier (Mutua *et al.,* 2010). There was also ready market for piglets locally thus local movement of pigs for rearing was common as observed from other studies (Mutua *et al.,* 2010; FAO, 2012; Kagira *et al.,* 2010a). Another factor that encouraged much localized trade was the means of transport with households relying on motorcycles or trekking the pig to a buyer. Across border trade of pigs was reported during interviews and also witnessed from the networks. The pig business was more of a localized business but with connections that spanned across the area. Value chain actors traded with people they knew about more than those they did not know well. The only exception is that when there was an outbreak of ASF where households sold to unknown traders as reported earlier in this study. Close relationship and sharing of the same geographical region would make households more likely to have their pigs infected in an outbreak and also collaborate to prevent spread of disease onto their farms by collaborating for biosecurity. Agistment was more to relatives and friends, selling and purchasing was more to neighbours. Agistment seemed to require trust and was so was informed by relationship and reason; contrasting to selling and purchasing relationship by distance (which neighbours were in short proximity).

Movement of pigs between villages or households during service increased the risk of ASF disease spread because no biosecurity measures were observed when the sow or boar was brought to the temporal households or when they were returned to the owners. Sharing of boars by smallholder farmers was common because most households did not rear boars as observed in other studies (FAO, 2012; Okoth, 2012). According to biosecurity principles, when introducing a new pig to a farm, it is supposed to be separated from the others for 2 weeks just to be sure the 14 day incubation period for ASF virus was completed ensuring that no disease was transmitted (Muhanguzi *et al.,* 2012; FAO, 2011b). Observance of this period was a challenge because households would look for a boar when the sow was on heat thus allowing the separation period would mean the sow would have passed the service period and therefore not conceive. Movement of boars for service was also reported as one of the causes of outbreaks of ASF in some instances thus boar/sow movement for service increased the risk of ASF outbreaks and spread. Indeed some of the AHSP in the study area attributed some of the ASF outbreaks to boar movement. Earlier studies have implicated boar movement as source of ASF infection if not managed well (Greg and Graeme, 2006; Okoth, 2012).

Most households cited lack of boars for servicing the sows as one of the constraints towards pig production as has been observed in past research (Muhanguzi *et al.,* 2012; Mutua *et al.,* 2011a). The recommended boar to sow ratio is 1:20. In extensive conditions, between 15 and 18 sows per boar is acceptable (Greg and Graeme, 2006). The boar to sow ratio in the study area (1:6 for Kenya and 1:7 in Uganda) exceeded the recommended. However, despite the high ratio, most households cited lack of boars for servicing the sows as one of the constraints towards pig production most likely due to the expansiveness of the area and therefore boars were far off from households that needed them. Sharing of boars by many households was likely to lead to poor breeds of pigs because of inbreeding. Artificial insemination could be one of the options of dealing with these shortcomings. Artificial insemination has been used

in pigs successfully and can be carried out by nonprofessionals when trained, (www.pork.org., www.thepigsite.com/artificial-insemination).

In the current study, a village was considered as a single epidemiological unit of risk because pigs in villages have direct contact among each other as seen from the networks thus social network analysis is helping in identifying groups of premises that, due to a high number or frequency of direct contacts among each other, behave as a single epidemiological unit (Martı´nez-Lo´ pez *et.al.,* 2009). In the event of an ASF outbreak, the village should be quarantined to effectively stop spread of disease taking other epidemiological factors which may include neighbouring villages into consideration. Currently the local veterinary authorities only impose quarantine in outbreak and neighbouring households (Personal communication).

Pig trading was very dynamic based on the fact that most of the traders had been in business between 1- 5 years. There were many traders that were operating in the area as mentioned by those that were interviewed. The big number of traders may have been a pointer towards the high pork demand in the area thus a ready market. Pig traders traversed through villages to purchase pigs. Pig traders moved from homestead to homestead and from village to village looking for pigs to purchase. The ASF virus is shed in body secretions and faeces and contaminated material may be moved over distances by people (FAO, 2000). As traders moved no biosecurity measures were observed to avoid spread of infectious diseases (FAO, 2012). This network feature increased the risk of spread of disease for instance if a trader within the network moved to infected households or purchased pigs from a village that was infected with ASF virus and sold pork to other villages, the disease could easily spread through the trader movement network. This concurs with a study in Nigeria which showed that ASF appeared to infect pig farms in a pig trade pattern (Fasina *et al.*, 2012; Atuhaire *et al.*, 2013b). The traders' movement network also crossed national borders. Illegal trade in pigs

across borders posed the risk of spread of ASF between countries (Etter *et al.,* 2011). Although some of the households and traders mentioned buying pigs across the border, none of them mentioned that they obtained import permits from the veterinary authorities to move the pigs. This implied that pig movement took place within the study area without the knowledge of the veterinary authorities. Education of the producers and traders on the importance of documentation will increase compliance. Pigs smuggled across the border increased the risk of introduction and spread of ASF. There were already initiatives for cross border collaboration by the Kenya and Uganda government to curb cross border spread of ASF but facilitate trade between the two countries. The current marketing practice may have played a role in the spread of ASF (Penrith *et al*., 2013). A butchery sold pork to many different villages in a day as portrayed in the networks. With minimal or no meat inspection as seen earlier in this study and as reported by Pezo and Rösel (2012) such butcheries would easily sell ASF infected pork to these villages and therefore disease spread. Lack of a centralized slaughter slabs and unreliable pork inspection increased risk of ASF spread because pork meat and was probably one of the most important media for spread of ASF infected meat. Unregulated pork movement has also been incriminated in most of the outbreaks that have been reported (DVS, 2001; Muhanguzi *et al.,* 2012). There was a greater risk of ASF spread along the pig and pork movement networks if infected pork was involved.

The results presented in this Chapter showed that underlying close social networks (family ties, friendship neighbourhood etc) were essential for the local pig trade in the study region. While pigs are central in the pig movement network there are social networks that share knowledge, beliefs, norms and practices, and information some of which contribute to the dynamics of ASF spread, emphasizing the importance of human behaviour in ASF management (Penrith *et al.*, 2013). If there is a disease outbreak in a network, information flows and the people concerned modify their behaviour and act based on the information and

their perception. This will in turn affect the pig movement network functions and structure as observed earlier where most households sell off their pigs to avoid losses to disease in case of and ASF outbreak (FAO, 2011b). Attitudes and beliefs can be transmitted between people in a network like communicable diseases (Christakis and Fowler, 2013).

The purchase and sale networks formed were one component; while the agistment boar service and traders networks had several components. Pig movement was mostly within 5km and sometimes long distance movement especially when there was a rumour or outbreak of ASF. The density in the three networks was below 0.01 showing that not all the villages were connected. The modularity ranged from 0.2 – 0.5 showing community structure (good quality clusters) within the networks. The normal range for modularity is between -0.5 to 1 (Newman 2006). Modularity compares the expected number of edges within communities to the actual number of edges within communities (Danon *et al*., 2011). It is positive if the number of edges within groups exceeds the number expected on the basis of chance. A closely connected social community will imply a faster rate of transmission of information or rumour among them than a loosely connected community. Componenting in a network with the possibility of long distance contacts makes networks easily navigable for diseases. Within the clusters in a component, with an average path length of 5, disease would easily reach every node in a cluster. The community structure implies easier flow of knowledge and resources between people, groups and organizations involved in an enterprise (Clottey *et al*., 2007). The pig network formed in this study has the small world phenomenon. Componenting and short path lengths refer to small-world networks (Watts and Strogatz, 1998). In small world networks, small number of steps, on average, are needed to reach any node in a network with an increased probability of one's neighbours being connected to each other, (Dube *et al.,* 2009). Movement of pigs by agistment, boar service and AHSPs when treating pigs, though short distant movement, would equally spread disease within the network. As seen from the

relationships of people involved in pig movement, they were either related or there was mutual trust. As much as these networks are used for pig movement, they are important in disease introduction and dissemination (Martı´nez-Lo´pez, 2009) in diffusion of information, adoption of attitudes and beliefs (Christakis and Fowler, 2013; Valente and Fosados, 2006). The complexity of the pig movement network may explain why there are always outbreaks of ASF in the study area because any pig movement no matter what level is significant in disease spread due to the interconnectedness of the networks within and without villages. When there is an outbreak of ASF, all the villages that are interconnected should be put under quarantine to control disease spread efficiently and effectively. This effectively means that not only can a disease spread to local components, but it can also spread to components which are topologically distant in the network (Dube *et al.*, 2009). In the purchase and sale networks, the maximum degree greatly exceeded the average indicative of hubs (popular destination) for pig purchase and sales. The highest degree nodes are often called "hubs". once the hubs are infected and have infected their partners, infection then spreads more slowly than on random networks (Kiss *et al.*, 2006a,b), which can lead to smaller epidemic sizes (Kao *et al.*, 2006). In the networks formed, slaughter slabs in Kenya were probably major hubs for disease spread and information about ASF outbreaks thus disease control information would target such sites. This has shown to be an effective way of obtaining of information (May and Lloyd, 2001; Kiss *et al.*, 2006c). The networks were also more dense in villages that had markets, thus these villages were areas of disease introduction and spread as observed by Martine`z Lopez (2009) and such should be targeted for control information and effort.

A potential limitation of the current network study was that the information available was only for certain nodes of the network, because data were collected through questionnaires administered only to certain farmers of a network. The inferences made were based on values obtained from a sample of nodes of the network, but the network metrics were unbiased

because the sampling method used to select the individuals did not introduce any systematic error. Undoubtedly, quality of results are never better than the quality of the information used to feed into the network thus quality data is a pre-requisite to good results.

Social network analysis is a tool that is being used to implement policies and strategies aimed at tracing the origin and route of food animal trade. Thus, SNA has important applications and impact on animal disease surveillance and contingency planning (Martı´nez-Lo´ pez *et al.*, 2009). In the current study, the trader networks were important in the control of ASF. Traders should be targeted selectively as part of prevention or control scheme. They were the first to hear about an outbreak when contacted by households that sold suspected ASF pigs, purchased pigs which may be infected, transported the pigs through the villages, used slaughter slabs that were most likely not licensed and sometimes sold infected pork to unsuspecting clients. Social network analysis is a useful technique to identify such individuals that are important in terms of risk for disease introduction, disease spread, or disease maintenance and dissemination.

CHAPTER SEVEN

ADVICE AND TRUST NETWORKS IN BUSIA KENYA, AND BUSIA AND TORORO UGANDA

7.1 Introduction

Identification of advice and trust networks gives the pathways through which information can best be passed to the intended recipients. This chapter set out to identify the advice and trust networks of pig keeping households and traders and how they can be used for information dissemination and influence.

7.2 Materials and Methods

The results from this chapter are drawn from the materials and methods described in chapter 3. Data was exported to Microsoft excel and analysed using descriptive statistics. Data used in this chapter was based on where households obtained information that was important to households and pig rearing, how they started pig farming and who influenced their decision to start pig farming.

7.3 Results

7.3.1 Sources that influenced households to start pig keeping enterprise

The idea of pig-keeping by the different households was initiated due to various reasons as shown in Figure 7.1. Over 60% of households in Kenya and 70% in Uganda ventured into pig-keeping after observing from other pig-keeping households. More than 10% of the households in both Kenya and Uganda had families that were always keeping pigs. There are also other factors that convinced these farmers that pig-keeping was a viable enterprise i.e. who influenced them to start keeping pigs.

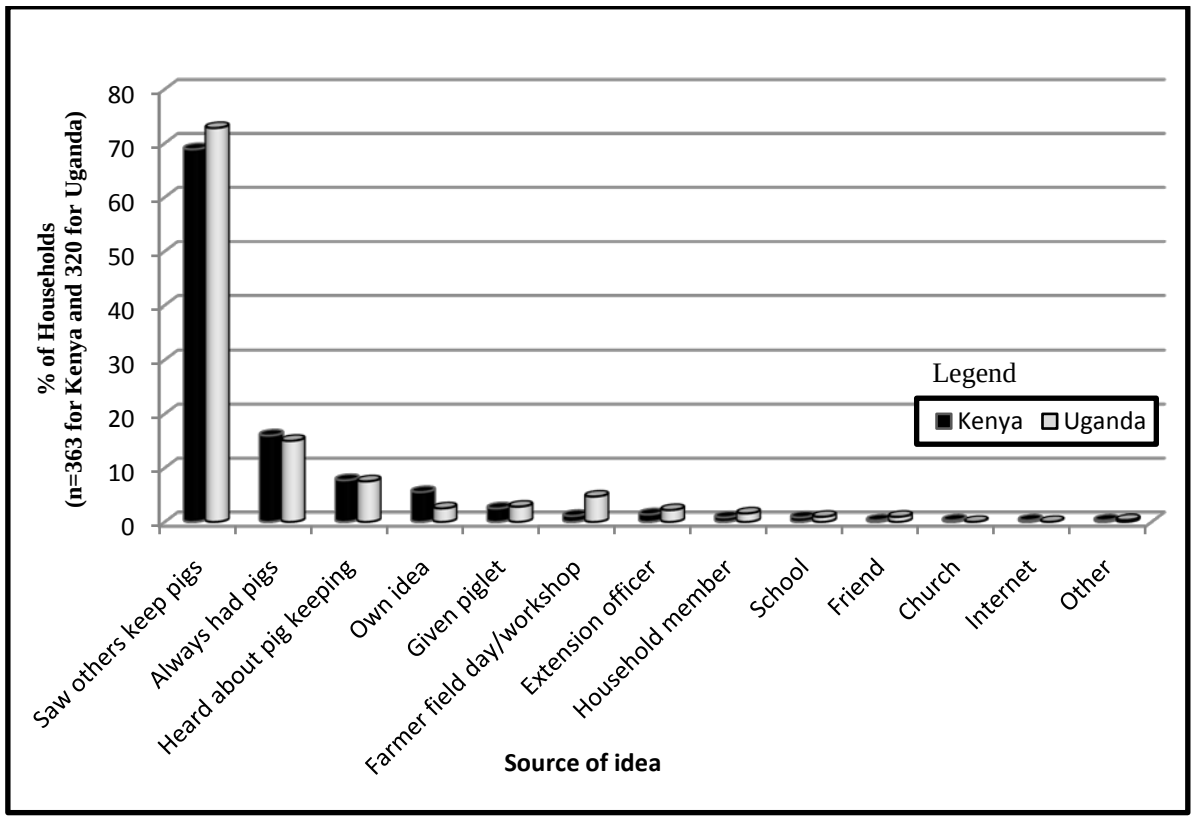

Figure 7.1: Source of ideas for household pig-keeping in Kenya and Uganda

Figure 7.2 shows the different categories of persons who managed to convince or demonstrate to households that they could benefit from pig-keeping. The 683 households sampled were mostly influenced or given ideas by neighbours (Kenya, 28%; Uganda, 20%), relatives

(Kenya, 20%; Uganda, 26%), self (Kenya, 25%; Uganda, 21%), household member (Kenya, 15%; Uganda, 21%) and friend (Kenya, 11%; Uganda, 12%) in decreasing order to start keeping pigs. Influence emanated from people who they interacted with most times or someone related to them. After seeing the impact of pig-keeping, the households would get convinced that pig-keeping was something that could benefit them. They also had points of reference if they encountered a problem when they started the pig-keeping enterprise. The influence from livestock health officers and farmer organizations was low.

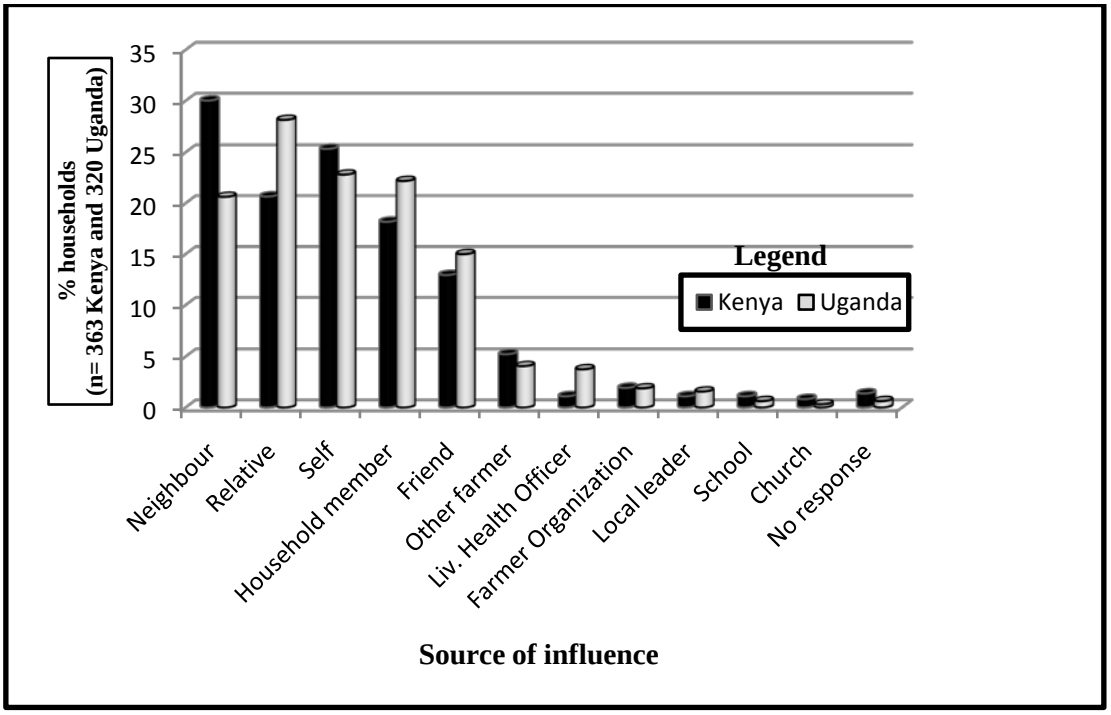

Figure 7.2: Who Influenced households to start pig-keeping in Kenya and Uganda

7.3.2 Source of information and help for pig keeping households

The actors in the pig enterprise obtained information from varied sources depending on the need. During the study, respondents were asked where or how they obtained information that was helpful for farming and other household issues. The most important sources of information were family friends, media and local leaders as shown in Figure 7.3. Out of the 363 respondents from Kenya and 320 from Uganda, family/friends were the major source of general information for households. Media was the second important source of information

and this included radio, television and print media. According to the wealth data collected in the study, 71% of the sampled households owned a radio, and any news aired reached the others who did not own radios through neighbours. Households also got information from the local leaders through meetings organized locally ('*Barazas*') and when they went personally to the local leader's office. In Uganda, respondents also got information from the National Agricultural Advisory Services **(**NAADS) which was categorized under government. The NAADS was a government initiative that assisted households improve their food security through farming, with pig keeping as one area of activity

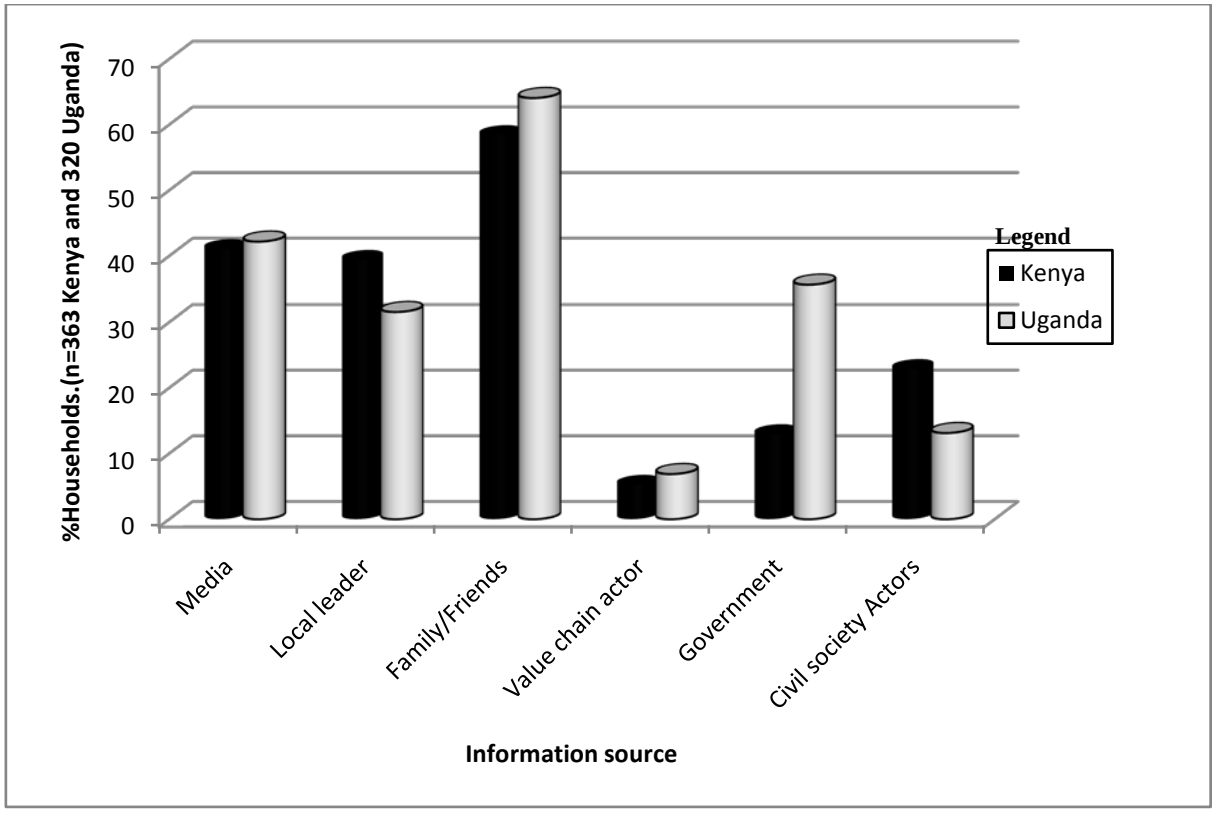

Figure 7.3: Source of information that was helpful for farming or other family and household issues in Kenya and Uganda, 2012

When a problem was on the farm, households in both Kenya and Uganda sought help from people they were close to (Family/friends) followed by the local leader, then government and from organizations they belonged (Figure 7.4). According to these data, many households sought for help from individuals they trusted or were close to when they had a problem on

their farm. The local leaders informed them whether the problem they were facing was localized or was affecting other households within the village or other villages.

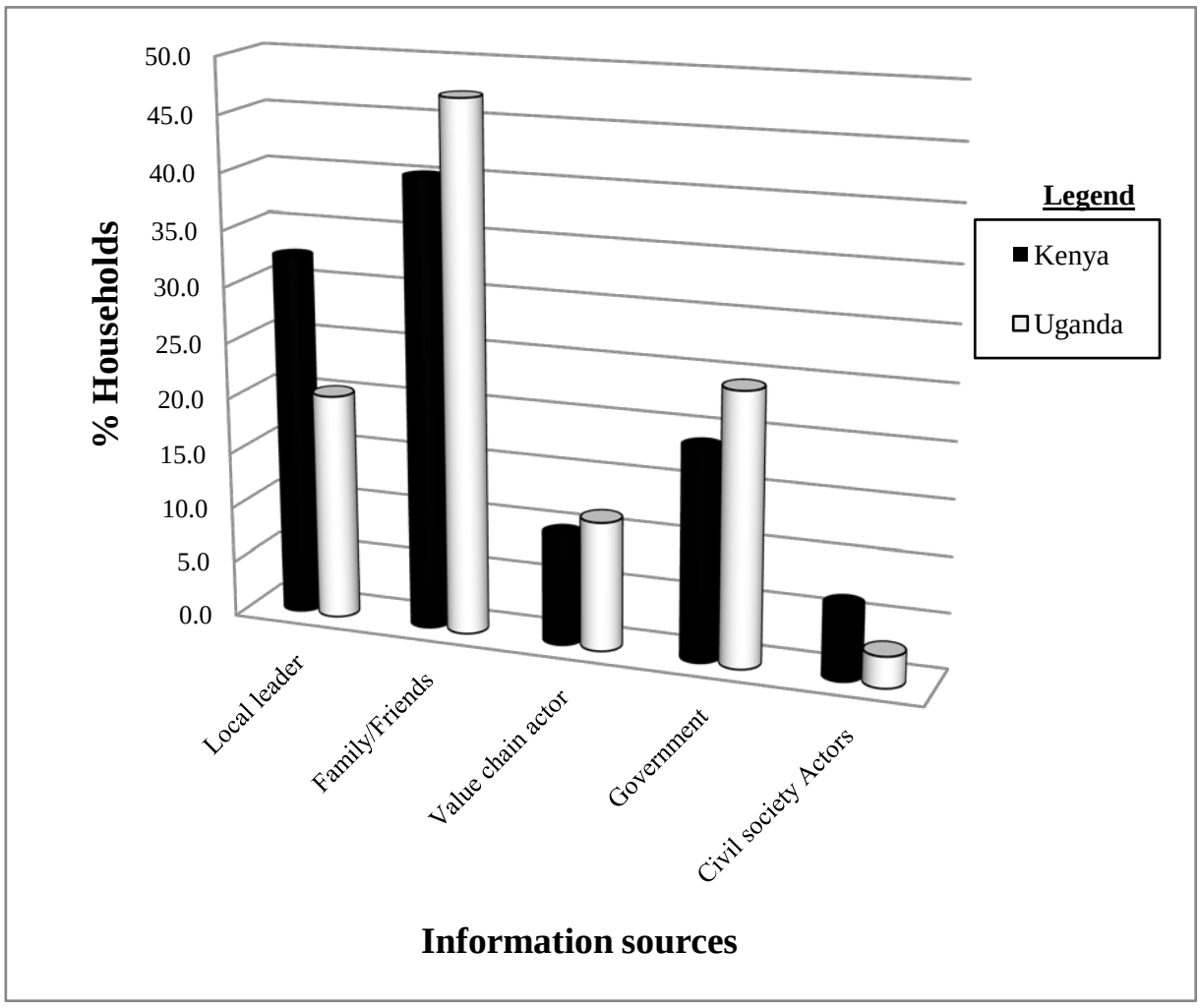

Figure 7.4: Source of information when households had a problem on the farm in Kenya and Uganda, 2012

In case a household had a problem with pig keeping, they sought for help from different sources as shown in Figure 7.5. When households had a problem with pig keeping, they first and foremost sought help from government authorities. Family and friends were also key sources for seeking help; 20% of households in Kenya and 30% in Uganda. The local leader and value chain actors were third and fourth in rank.

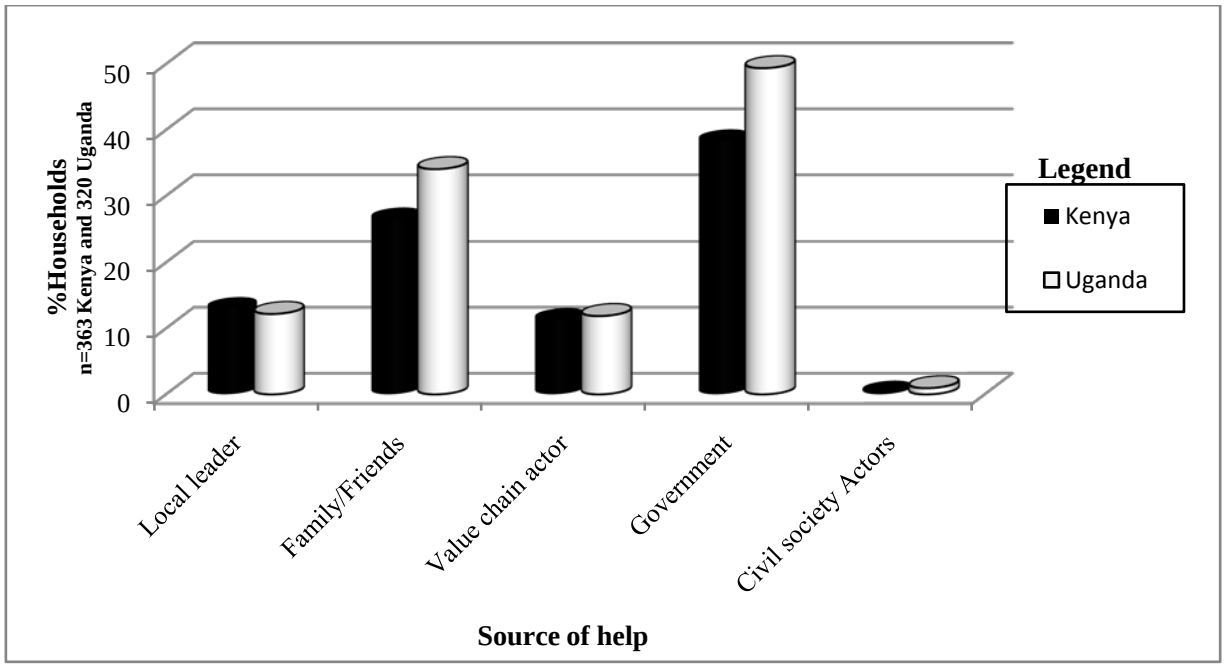

Figure 7.5: Source of help about pig keeping in Kenya and Uganda, 2012

Combined data of ASF outbreak experience, whether the pig they had sold previously and the pig in the household at the time of sampling had ever been sick were used to ascertain where households went for help when they had a sick pig. Using these data 192 Kenyan households had had sick pigs and 94 had sought for help, while in Uganda 185 had had sick pigs and 82 had sought for help. The sources of help are shown in Figure 7.6. When pigs were sick, (48% in Kenya and 29% in Uganda) households sought for help from Private Service Providers followed by the government. The value chain actors and people close to the households still played an important role when pigs were sick. The households interviewed went to the government veterinary authorities for advice but were much more likely to go to the private service providers when they needed treatment services for their pigs.

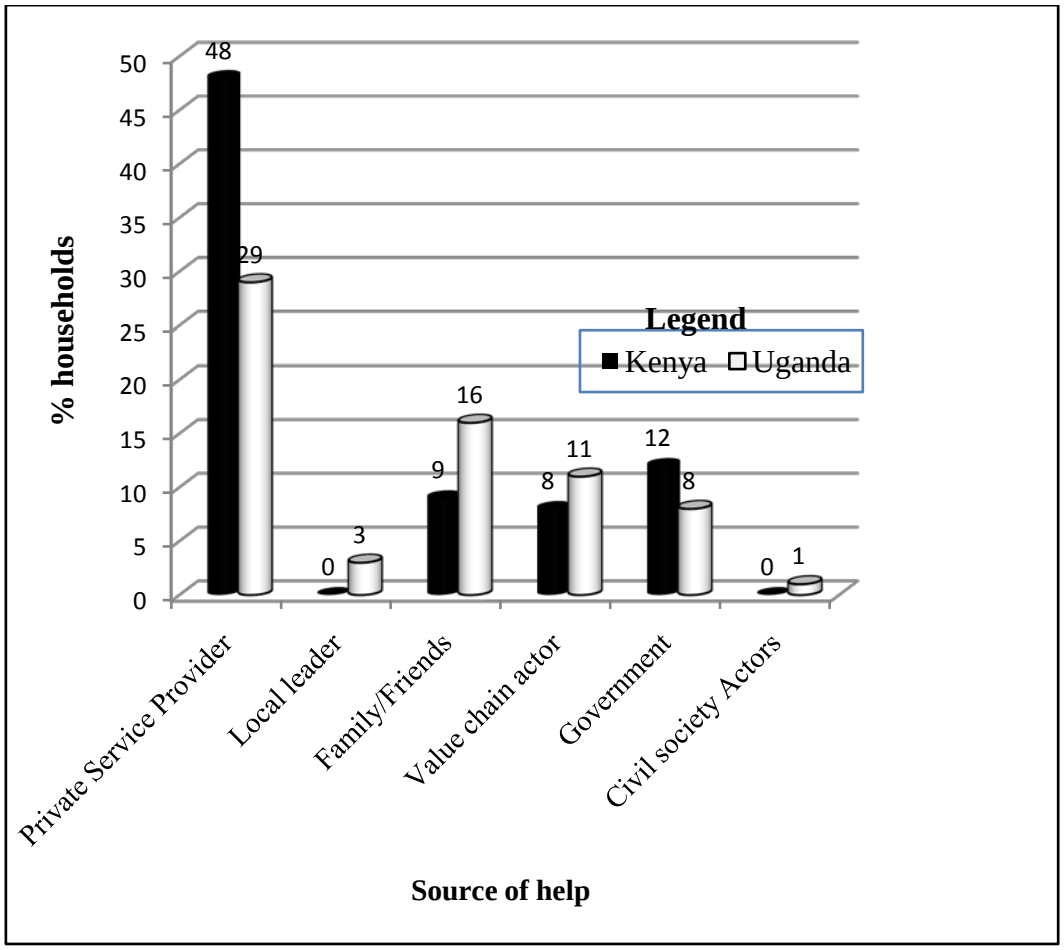

Figure 7.6: Sources where help was sought for sick pigs in Kenya and Uganda, 2012

7.3.3 Interaction between traders and animal health service providers

The sampled households interacted with all actors within the pig value chain and they did so according to who they perceived would sort out their issues at hand. There was minimal collaboration between traders and government animal health service providers. In Kenya, out of the 17 traders interviewed, 10 (64%) had never interacted with the animal health service providers while 16% had at one time within the year reported sick pigs to them. In Uganda, nine (56.3%) out of the 16 traders had interacted with animal health service providers during outbreaks of ASF when they were being sensitized on how to recognize ASF, training, public health campaigns and when imposing quarantines. Traders mostly relied on colleagues in business to get advice and help on how to run their business.

7.3.4 Organization among traders

The traders (50% in Kenya and 75% in Uganda) belonged to a common interest group although not related to pig farming. They got together as traders of different commodities and formed saving groups that assisted them with loans to boost their businesses. Only one of the traders had applied for a loan to boost the pig business but all the others took loans for other business ventures. There was no formal organization by the traders with common interest in pig at the time of the interviews but after, the Busia Uganda traders formed an organization arising from the advice of the project staff and the Busia Uganda Veterinary officer. They understood that working together with the veterinary office when they were under an organized group was beneficial.

7.3.5 Animal health service providers services

In Kenya, a total of eight AHSP were interviewed, six had a Diploma in animal health; one a certificate in Animal health, and one with primary education. Six of the (AHSP) were private practitioners while two worked for the Department of Veterinary Services. In Uganda, six animal health service providers were interviewed. Three were Animal Health Assistants, two were veterinarians and one was not trained (sold some veterinary drugs in his hardware shop). Three of the service providers were employed by The National Agricultural Advisory Services (NAADS), one by Ministry of Agriculture Industry and Fisheries (MAIF), one by the Local government and the one that was not trained was a private service provider. In Kenya the services offered by the AHSPs were management services (deworming, ectoparasite control and iron injection), treatment of clinically sick animals, laboratory services and extension. In Uganda the local government service provider interviewed was offering treatment services while the NAADS and MAIF offered advice only. The only private AHSP interviewed in Uganda sold drugs only and was stationed where there was no veterinarian posted by government, NAADS or MAIF.

The AHSPs interacted with the farmers when they visited their offices or the farmers called them if they had their mobile phone contacts. The service providers reportedly attended to many more cases during the dry season as compared to the wet season. The services providers explained this by the fact that during the dry season when feed was scarce, the pigs were undernourished and therefore prone to many ailments. During the wet season, pigs were well fed and therefore healthy thus did not easily succumb to infections. The private service providers usually attended to pigs in their home areas. The local farmers were familiar to them and they charged fairly for services rendered compared to their government counterparts. Government AHSP operated from offices thus always needed facilitation to reach farms unlike the private, who were within the community.

7.4 Discussion

The results showed that households obtained information from sources/individuals that were trusted and close to them. Indeed most households started pig keeping when they observed it from their neighbours, relatives or friends thus demonstrating the "*seeing is believing*" mentality. This implied that demonstration was a powerful tool in adoption of new practices for example, when changing practices such as bringing in biosecurity, seeing a demonstration would facilitate adoption. Practical extension and training has been observed to enable farmers raise pigs successfully (FAO, 2011a) as witnessed from the area of study, households started pig farming when they saw others doing it. Demonstrations were used in Ghana to lure farmers carry out routine vaccinations in small ruminant when they were carried out in their communities and nearby ones in Tolon-Kumbungu District (Clottey *et al.,* 2007). The power of demonstration has also been used in Kenya (FAO/KARI/ILRI 2003) through *'Farmer field schools'* (FFS) to improve various farming activities in the country and has been expanded for use in livestock (Groeneweg *et al.,* 2006). Farmer field schools simplify the research messages to be clearly understood by small scale farmers and lead to a deeper understanding

of a problem and its causes. They also ensure that knowledge is acquired by a group as opposed to individual farmers' thus faster knowledge dissemination and adoption. The FFS schools can be adopted in dissemination of information because members know one another and therefore some level of trust has been built. In Indonesia, farmers from FFS groups used the same principle for diverse activities aimed at improving their livelihoods (Susianto *et al.,* 1998). Most pig keeping households were people with low literacy levels and so through demonstrations as used in FFSs, it is easier to reach such groups or people. The already existing trust among the pig farmers can be exploited by providing information about pig production, health and marketing through farmer-to-farmer extension (Penrith *et al.,* 2013). These networks can thus be used for change in the beliefs and social/cultural/ norms of the farmers, traders and the service providers. To help in adoption of new pig keeping and trade practices, demonstrations can be used to hasten adoption just as on FFS that have been used in other livestock (Groeneweg *et al.,* 2006). The already existing trader and farmer organized groups can be used for support and knowledge dissemination about ASF just as were used in Indonesia (Susianto *et al.,* 1998) and in Australia (Fuller *et al.,* 2007) to reach farmers. Apart from getting information from close contacts, smallholder farmers also got up to date information from the media, usually the local FM vernacular radio stations. Local FM vernacular radio stations that most households listen to can also be explored as an avenue for strengthening the dissemination of general information about ASF disease and occurrence of outbreaks. Local leaders were trusted by households thus given the right information about ASF control would be very instrumental in information dissemination. Despite the fact that government officers were equipped with information about pig keeping, their influence on pig keeping was low probably because they only gave information without demonstrations.

Local leaders were the custodians of all happenings within their areas of jurisdiction. They got to know the happenings in adjacent villages and so were well placed to give their subjects up

to date information. Governments worked in such a way that every morning the local leaders passed information through the chains of command, both upwards and downwards. This gave the central government an upper hand in dealing with issues that needed attention and also for monitoring situations within the villages. Given the right information about ASF control, local administration would be very instrumental in disease reporting.

The National Agricultural Advisory Services in Uganda was a source of general information for households when they had a problem on their farms and pig-keeping. Almost half of the households that reported to have had sick pigs never sought their help. In Kenya, 94/192 (48.9%); Uganda 82/185 (44.3%) households that reported to have had sick pigs in the household sought for help. Work carried out in Uganda also recorded 76.2% farmers who had experiences a disease problem on the farm, only 55.3% consulted a veterinarian (Muhanguzi *et al.*, 2012). This could be partly explained by the fact that households tend to believe that when a pig got sick it would die, regardless of whether the disease was ASF or not, and so there was no need to waste time and money on treatment. In this study, households were also unable or were just not willing to pay for pig treatment services which were one of the challenges of AHSP. Unwillingness to pay for services rendered has also been reported in earlier studies by Mutua *et al.,* (2011a) and Wabacha *et al.,* (2004). When the cost of treatment was more than KSh 50, pig owners preferred selling the pigs. Considering the free-range production system (Mutua *et al.*, 2010; Okoth, 2012) pig owners invested minimally and therefore not keen on keeping the pigs when they were sick. The poor competence of the AHSP in this study about pig ailments probably discouraged households from seeking for help. Smallholder farmers seemed to know where to source for advice when pigs had a problem, i.e. service providers employed by the government. Many of the smallholder farmers interviewed sought for advice from public/government officers, free of service charge. When their animals got sick, they went to seek for help from Private Service providers, a clear need

of treating sick pigs as observed by Alawneh *et al.*, (2014). The public service providers were considered expensive because they requested for transportation to the farm or household. In addition the farmers feared that government would impose quarantine restrictions if the pigs were found to be infected with ASF virus, and thus would lose their investment. Private AHSP were readily accessible because they stayed within their own home areas, and therefore did not require provision of transport from the farmers. Some of the private service providers are not trained and were therefore carrying out mis-diagnoses, inappropriate treatment or inadequate and poor disease prevention measures. Given that private service providers were more involved in treatment than the public (Government) service providers, regulatory authorities could achieve significant improvement in pig production efficiency by strengthening collaboration between private and government service providers. The private service providers could also be equipped with the right knowledge by the governments to improve disease diagnosis and therefore early detection and control. There is need for a deliberate strategy by the governments of Kenya and Uganda to create collaboration between the regulators, smallholder farmers, and the traders. The collaboration between the veterinary authorities and the traders should be enhanced where it already exists or initiated where there is none to encourage disease reporting and information flow. Sharing of information between the private and public AHSP should be encouraged. There should be a mechanism in place whereby an inventory of all the private service providers and their area of operation is available for ease of follow up. These private AHSP should be compelled to report the cases they encounter in their line of duty daily to the government officer in charge of the area. A system similar to the one where local leaders get daily reports from their juniors can greatly improve reporting and prompt disease control. There should be penalties spelt out for those who circumvent compliance. This can be done through education of the service providers and the registration process carried out within a specified period. Collaboration with the private

service providers will assist governments in service delivery because most are not able to engage adequate numbers of service providers to serve the farmers.

The linkage between animal health service providers and the traders was weak because the traders associated the service providers with imposition of quarantine which they believed was meant to punish them. Traders mostly interacted with the animal health service providers when imposing quarantine. The animal health service providers were therefore viewed as enemies by the traders because they only appeared when they were instructing them to close down their businesses during quarantine imposition. This may explain why most of the traders used nicknames when running their business and they were initially reluctant and they asked many questions to make sure they understood the purpose of the interview before agreeing to participate.

The traders interviewed belonged to organizations that were constituted for economic/ financial purposes that were not related to pig keeping. As observed by Susianto *et al.,* (1998), such organizations can be adopted for support and knowledge dissemination about ASF such as the one formed in Busia Uganda in 2013 after the project interviews. Farmers or traders can benefit from organizations by securing credit from government agencies (Mutua *et al.,* 2010) because the group is an automatic guarantor especially for those without assets. Farmers would also have market control for their pigs (Mutua *et al.,* 2010). Belonging to organizations has enabled smallholder farmers access markets (Penrith *et al.,* 2013), which could not be possible if operating individually. Advice and trust networks are important because action to reduce the incidence and impact of ASF will be easier and cheaper to implement if it builds on established trust relationships as used in Australia (Fuller *et al.,* 2007), whereby available frontline rural support workers who offered essential services (agriculture, finance and drought support) to rural people were used to reach farmers with mental health problems where mental services were not available despite having no expertise.

They were only trained and linked up to the trained service providers. In situations where no trust relationship exists between people whose behavior influences ASF spread, or who could be important to ASF control, then new relationships will need to be built.

CHAPTER 8

FOLLOW UP STUDY RESULTS ON SELECTED HOUSEHOLDS IN BUSIA KENYA, AND BUSIA AND TORORO UGANDA

8.1 Introduction

The follow up study was carried out to follow up sentinel pigs in 120 households. The first follow up sampling was carried out in February 2013 with the second in August 2013. A questionnaire was also administered to find out the number of pigs acquired, sold and if there was any change in pig management practices over the six month period. The objective was to follow up the sentinel pigs for exposure to ASF virus and gather any changes in pig keeping within these households.

8.2 Materials and Methods

One-hundred-and-twenty households (60 in Kenya and 60 in Uganda) with pigs between 3-4 months of age were randomly selected from those that participated in the cross sectional study to participate in the follow up study. Information about the follow up study was given to the participating households (Appendix 10) and they signed a consent form once they agreed to take part in the study (Appendix 11). The follow up studies was conducted over a period of 6 months in the region (3 samplings, i.e. baseline, 3 and 6 months). One pig within the households participating in the follow up study was purchased and left in the care of farmers as ‘sentinel pigs’ (3-4 months old pigs that were negative for ASF antibodies) for monitoring ASF during the course of the study. Although one pig was identified as a sentinel, all the pigs within the selected households were sampled during the follow up study so that if the chosen sentinel pig died or was no longer in the household, a replacement would be sought from the same household. The cross sectional data provided the basis for the design of in-depth questionnaires for the follow up study (Appendix 12). During the sentinel pig study, more information about pig movements was obtained and source of information was established.

Whole blood and serum was again collected from the pigs. The whole blood samples were screened for ASF antigen using Real time PCR (Zsak *et al*., 2005) and Conventional PCR (SOP/CISA/ASF/PCR/1/2009). The serum samples were screened for ASF virus antibodies using ELISA (SOP/CISA/ASF/ELISA/2/2008). At the end of the project period, the pigs reverted back to the owners. Data was uploaded to Microsoft excel and analysed using descriptive statistics.

8.3 Results

In this study, the number of pigs that were acquired or sold by the households that had sentinel pigs are as shown in Table 8.1

Table 8.1: Category and number of pigs sold or acquired by households that participated in the follow up study

Country	Pig Category	Number of new pigs to households and their fate				
		Bought	**Sold**	**Dead**	**Stolen**	**Agisted**
Uganda	**Piglets**	128	40	7		2
	Weaners	7				
	Boar	1				
Kenya	**Piglets**	84	41	33	1	3
	Weaners	10	15			1
	Boar	1	4			
	Sow		1			

In the 120 households 231 pigs had been acquired and 91.7% (212/231) were piglets that were born on the farm. It was found that most households bought piglets. Households in Uganda had only sold piglets while Kenyan households had bought all pig categories. The deaths that occurred in the households were of piglets. Two households in Uganda and 4 in Kenya had agisted pigs to relatives at the time of sampling.

The relationship between households that had purchased and sold pigs is shown in Table 8.2.

Table 8.2: Relationship of households with people they purchased or sold pigs.

Country	Relationship of households that bought and sold pigs					
	Friend	**Neighbour**	**Other farmer**	**Relative**	**Trader**	**NAADS**
Purchase						
Uganda	1	1	3	4	0	0
Kenya	1	5	1	0	0	0
Total	**2**	**6**	**4**	**4**	**0**	**0**
Sale						
Uganda	0	4	0	2	4	1
Kenya	0	5	0	7	11	0
Total	**0**	**9**	**0**	**9**	**15**	**1**

In Kenya, households purchased pigs from neighbours and few from friend and other farmer. Ugandan households purchased their pigs from relatives followed by other farmer and few from friend and neighbour. Households in Kenya sold pigs mostly to traders then relative and neighbour. In Uganda sale of pigs was to traders and neighbour, then to relative. Neighbours and relatives purchased pigs for rearing while traders most times purchased for slaughter.

Table 8.3 records how far households purchased or sold pigs.

Table 8.3: Distance households purchased or sold pigs

Country	Purchase and sale distance			
Purchase	**<1km**	**1-5 km**	**5 - 10 km**	**>10 km**
Uganda	4	4	0	1
Kenya	4	3		
Total	**8**	**7**	**0**	**1**
Sale				
Uganda	6	4	2	0
Kenya	12	8	0	3
Total	**18**	**12**	**2**	**3**

The purchase and selling of pigs by households was done within a radius of 5 km.

When households sought for advice or help, they went to different sources as shown in Table 8.4.

Table 8.4: Source of help or advice

Source of Advice/help	**Country**		
	Uganda	Kenya	Totals
Livestock/NAADS	5	4	9
Agrovet	1	0	1
Local leader	2	1	3
Neighbour	1	1	2
Other farmer	1		1
Relative	1	1	2

The source of advice or help was from livestock officers and others went to the local leader. Some households also sought help from neighbours or relatives. The other households had not sought for any help during the follow up study period.

In both countries, pigs in 19 households had been sick and only 9 had sought for help.

The 371 follow up blood samples (216 collected after 3 months and 155 after the sixth month) were also negative for ASF antibodies and ASF virus DNA. African swine fever virus DNA was however detected in tissues of one pig sacrificed at the end of the study for examination.

8.4 Discussion

In this study, households acquired pigs when a household sow farrowed forming the larger share of new pigs within the household. Results from the cross sectional study also recorded pigs born within the household as a major way of acquiring new pigs. Piglets from zero to one month, dependent on sow milk putting a lower feed burden to the smallholder households. The farmers specialized in breeding (FAO, 2012) because of the low cost of feed for piglets and ready market locally (Mutua *et al.,* 2010; Kagira *et al.,* 2010a; FAO, 2012). The farmers only retained pigs that they would be able to feed, which normally ranged from 1-2 pigs per household (Mutua *et al.,* 2010). Piglets aged two to three months were sold to other farmers who raised them for slaughter (FAO, 2012). Those households without sows acquired piglets for rearing because they were cheaper (Mutua *et al.,* 2011) compared to older pigs. The number of piglets sold in this study were more compared to other pig categories. Earlier studies have attributed higher number of piglet sales to high sow fecundity and a sow farrowing twice a year compared to slaughter pigs that reach a market weight of between 50 and 60 kg within two years (FAO, 2012). Apart from pigs born within households, pigs were purchased from people they knew or had a blood relation (Neighbour, relative or other farmer). Purchasing of pigs from this study for rearing was localized because of the high demand as observed earlier, (Penrith *et al.,* 2013) and easy flow of information locally as observed in the cross sectional study. Households purchased pigs within a distance of 5km. and did not have to go to the market to sell pigs therefore sale of pigs was within short distances as observed in earlier studies by Mutua *et al.,* (2010). Just as observed in the cross

sectional study, this is a relational-distance trade whereby pigs are purchased mostly from neighbours/relatives and other farmers who also kept pigs. Agistment of pigs was also witnessed during the follow up study, involving mostly piglets. Piglets were agisted to households that wanted to start pig keeping as observed in the cross sectional study. This was the easiest way to enter the pig business especially for households that lacked finances to purchase pigs.

The sale of pigs by households was to trader, neighbour or relative. The numbers of pigs sold were more to traders because most were for slaughter and the sale distance remained within a radius of 5 km. During the follow up study, all the households interviewed remembered who and where they had sold pigs because there might have been no rumours/outbreaks of ASF during this period. During the cross sectional study, households had only sold pigs to unknown persons when there was a rumour/outbreak of ASF. Knowing the movement of pigs is important in disease trace back when there is an outbreak of ASF.

High piglet mortalities were recorded compared to other pig categories. The high piglet mortality (Mutua *et al.,* 2011) is attributed to inbreeding (FAO 2012) that encourages manifestation of undesirable genes that affects the survival of piglets. Sows farrow in the open and sometimes under poor sanitary conditions and piglets are neither given iron injections nor special care given to nursing sows and their piglets (FAO, 2012), further increasing the piglet mortality rate.

The local leader was still a trusted source of advice as observed in the cross sectional study, but Livestock/ NAADS (Representing government authorities) replaced the family/friends that were the main source of help. This may have changed because of the advice the households were given during the cross sectional study. The change in the source of information may be an indication that if farmers are given the right information, they are willing to change. To satisfy farmer needs, the weak extension networks, particularly those

addressing the needs of the pig farmer need to be strengthened to encourage farmer-extension worker interactions (Mutua *et al.,* 2010).

The habit of smallholder households not seeking help when their pigs were sick was a confirmation of observations from the cross sectional study. Only half of the households that had sick pigs had sought for help hampering early disease detection efforts. Past research (Muhanguzi *et al.,* 2012) has shown that most households do not seek for help when their pigs were sick because of inability to pay for service (Wabacha *et al.,* 2004). In instances where they sought for help, they preferred private animal service providers (Alawneh *et al.,* 2014) further encouraging collaboration between private and public veterinary authorities for early disease detection and control.

There was no antibody or antigen detection in the 371 serum and blood samples collected during the follow up study. The detection of virus in the spleen showed that ASF virus could be sequestrated in tissues without shedding of virus or eliciting an immune response. In pigs infected with ASF, there has been no evidence of viraemia for longer than 30 days in healthy pigs but the virus can be recovered from lymphoid tissue for a few months (Penrith *et al.,* 2013). It has been suspected that inapparent carriers among domestic pigs are playing a major role in maintaining the disease in the enzootic areas (CIRAD, 2013; Penrith *et al.,* 2013; Misinzo *et al.,* 2012, 2014). Persistence of virus in sero-positive pigs has been observed in Nigeria (Fasina *et al.,* 2012) but persistence of infectivity in healthy recovered pigs is unusual, if it occur (Penrith *et al.,* 2013). In contrast chronically diseased pigs shed ASF virus following infection with viruses of lower virulence as reported in Spain (Sánchez-Vizcaíno *et al.,* 2012). Surveillance carried out in Nigeria (Owolodun *et al*., 2010) has shown that carrier pigs may not shed virus but probably at one point in time the pigs may shed virus into the environment thus causing outbreaks. It is likely that some transmission may occur from recently recovered pigs or their tissues, but much more evidence is needed to confirm the

importance of long term carrier pigs in the maintenance and spread of ASF. However, ASF infection burns out when there are no longer any naïve pigs left to infect. Large high-contact pig populations provide a never ending supply of naïve pigs and can likely maintain circulation of ASFV indefinitely, as has apparently occurred in Sardinia between wild boar and free-ranging domestic pig populations (Rolesu *et al*., 2007). Research needs to be carried out to prove whether carrier pigs can shed the virus and under what circumstances this can happen. Since infected pigs cannot be detected clinically, abattoir surveillance coupled with laboratory diagnosis would give a representative status of ASF diseases in pig populations.

The pig enterprise was localized, farmers sought for help from trusted people, awareness on pig diseases to encourage reporting was a noted gap confirming cross sectional data findings. Arising from the change in source of information from family/friends to veterinary government authorities, small holder farmers showed willingness to change if given the right information.

CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS

9.1 Introduction

This section summarizes the findings and suggests recommendations on improvement on the control of ASF based on the social networks study.

9.2 Conclusions

- Pig farming is important to smallholder farmers in the study area but ASF represents a severe threat to trade and livelihoods.
- There was no strategy for targeted ASF surveillance during periods of increased pig movement.
- Pig value chain actors had heard about ASF but there was poor knowledge about the disease.
- There was unmonitored pig movement across the Kenya-Uganda borders.
- The association of ASF outbreaks with the swamp on Malaba river in Buteba county Uganda needs further investigation.
- There is need for further investigations on the role of carrier pigs in the maintenance and transmission of ASF in pig populations in the study area.
- The most critical control point for ASF is the pig and pork marketing stage that involves the farmers.
- There was lack of standard slaughter facilities thus no ante mortem inspection of pigs by the veterinary authorities was carried out allowing clinically sick or moribund pigs entering the food chain.
- There was also lack of standardized pork selling joints in the study region.
- The community structure in the networks imply faster rate of transmission of infection, information or rumour among actors. The advantage of a community structure is easier flow of knowledge and resources between people, groups and organizations involved in an enterprise.
- The social network tool was very instrumental in getting how good biosecurity practices information on pig keeping can easily be passed and adopted by the pig value chain

actors. Pig keeping households were very good at adopting what they observed and they trusted people they knew very well or had blood relations.

- Formation of organizations by farmers and traders can have considerable influence and contribute towards disease management and growth of the pig sector.
- The local leader was very instrumental as a source of information to the pig keeping households. Slaughter slabs were very important venues for information exchange among traders.
- There were weak linkages between the private sector and the veterinary authorities thus hampering disease control efforts.

9.3 Recommendations

The following suggestions are highly recommended to assist the control of ASF;

i. The Kenya and Uganda Veterinary authorities should develop an ASF control strategy to include all stakeholders.
ii. The veterinary authorities in the two countries should develop key ASF messages that can be readily spread through established trust networks; local leader to farmer, farmer to farmer and local media.
iii. The veterinary authorities in Kenya and Uganda should develop platforms for information exchange including farmer field schools, demonstration farms, women groups or pig keeping associations / organizations.
iv. The veterinary authorities should also enact standards for slaughter and marketing of pig and pig products
v. The veterinary schools should introduce social science studies as relates to disease transmission in the veterinary curriculum.
vi. The two governments should strengthen linkages between the private animal health service providers and the veterinary authorities.
vii. The veterinary authorities should harmonize and coordinate of ASF control strategies between Kenya and Uganda.

Way forward

- The most critical control point for ASF control is the farm level,
- Control strategy that is all inclusive and owned by stakeholders in the pig industry will be effective in ASF control.

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Appendix 1: Pig health and farmer livelihoods Project information for farmers.

Invitation to participate

We are doing a research project to understand pig-keeping by farmers in your area and how farmers' livelihoods are affected by diseases that make pigs sick. Research is a way to find answers to problems or questions that do not have good answers, or where people do not agree about what is the best answer. Our research will help find better ways for farmers and other people to keep pigs healthy.

We are visiting you to invite you to participate in this research. We are visiting all the farms in this village and some other villages in this area where people keep pigs. We chose the villages randomly, meaning that each village has the same chance to be included.

In this research we to want ask you questions about your farm, pig-keeping and trading pigs and take samples from your pigs. This will take about two hours.

Your consent to participate

You do not have to agree to participate in this research. You can say 'No' now, or you can say 'No' after you understand more about the research. We will not talk to any other people about your decision. If you do agree to participate we will ask you to sign the written consent form.

Organizations involved in this research

This research project is funded by the Australian Government through AusAid that is the Australian organization that provides aid to other countries. The overall aim of the funding is to help people in Africa with problems that affect the way that they grow food and trade food. This project is being undertaken by researchers from BecA-ILRI (Biosciences central and eastern Africa and the International Livestock Research Institute) with the Australian research organization CSIRO (Commonwealth Scientific and Industrial Research Organization).

What it means to participate in this research

We want to examine your pigs, take measurements, take samples of blood and faeces (*mavi*, in Kiswahili; *obussa* in Luganda) and make photographs of your pigs. This is to get information about the health of your pigs. Our team includes qualified vets and animal handlers and we use the best recommended techniques for this work so that the pigs are not harmed. However the pigs will make a lot of noise when we are sampling them.

We also want to ask you questions about why you keep pigs; the way you keep pigs; any problems you have with keeping pigs including diseases; and about other farm and household activities. This is to help us understand how keeping pigs fits in as part of your livelihood. We will also ask you to give us the names of people who you got pigs from or traded pigs to. This is to help us understand how the buying, selling and movement of pigs works in this area. We may also want to make some photographs of your farm and family to help us remember what your farm is like. We might want to use some of these photographs in talks or articles about the research.

We would like you to answer all the questions we ask. But, if there is a question that you do not want to answer, you can say “I do not want to answer that’. If there is a question that you do not know how to answer, you can say “I don’t know”.

After this visit we might want to buy one of your pigs and leave the pig in your care so that we can examine the pig and other pigs again within 3 and 6 months time and take more measurements and samples. We will choose the pigs that we want to buy fairly, so that every

farm with a young pig has an equal chance of selling us a pig. Today we will put a numbered ear-tag on the pigs that we examine so that we can identify the same pigs later.

We will keep your information private

The information you provide to us and the samples we take will be kept private. This means that we will not keep your name with the information and samples. We will mark the information and samples with a number instead of your name. Only the Project coordinator/ fieldwork leader Dr Edward Okoth and senior members of the research team authorized by the leader will be able to look up your name. We will do this if we want to contact you again about further testing and information.

We will store the samples from your pigs in cold storage. We will store the information you give us on computers. Only members of the research team will know the password to access this information.

When we use your answers to our questions in other parts of our research, we will not tell other people that you are the person who gave us this information. When we use the information about you or your pigs in our research reports, we will not use your name or the exact location of your farm. This means that people who read our research reports will not know if you participated or not, and what we found out about the health of your pigs. Other researchers may ask to do further tests on the samples we take from your pigs. Or they may ask to look at information that you and other participants provided. These researchers will not be able to find out your name from the samples or information.

Maybe some of the photographs that we take of your farm and family will be good to show other people when we give talks or write stories about the research. We will make sure we give you a copy of any photographs that we want to use in this way. We will only use the photographs to tell good positive stories. If you want us to tell other people your name and village/town name when we show these photographs to other people, we will do this.

Benefits and risks to participants

We are doing this research to help understand how to stop pig diseases and improve livelihoods of people who keep pigs or trade in pigs. These are big and complicated problems. This research will not provide all the answers that are needed. After the research is completed, we will provide information to veterinary authorities and local leaders and ask them to inform you and other people in this village about what the research found.

This research will not stop the risk of your pigs getting sick. But we will give you advice about the best, simple ways that we know to keep your pigs healthy. We will wash our boots and hands with disinfectant so that we don't bring diseases from other places to your farm.

During our research we may discover some disease that is very serious. We may need to tell the government veterinary authorities so they can take action to stop the disease spreading. We will tell the veterinary authorities the name of the village where we have found the disease. We will not give out any specific information about your pigs or your farm unless this is very important to stop lots of other pigs and people being affected by the disease.

Contacts for questions or problems about the research

If you have questions about the research after today, you should contact one of these people on the BecA-ILRI research team

Project coordinator and fieldwork leader

Dr Edward Okoth. +254-725-082-458

Farmer study leaders

Dr Noelina Nantima, +256 772 515 962

Dr Jacqueline Kasiiti, +254 733 707 685

Project leader, Dr Richard Bishop +254 710 831 851

We need to know if this research is causing problems for you or other people. If you have a problem from the research, please inform us. You can also report the problem to the leaders in your village and ask them to talk to us. Or you can report the problem to your District Veterinary Officer (DVO) who will communicate to us:

Kenya DVOs

Busia District, Dr Lukhale +254-720692080

Butula District Dr Denis Odhiambo +254-726 865 192

Nambale District Dr Alan Ogendo +254-723 312 854

Teso South DVO. Dr. Polycarp +254-788252210 /+254208004645/ +254736382788/+254-708905032/ +254720173446

Teso North DVO. Dr. Odima. +254-722625908

Uganda DVOs

Busia District Dr Barasa Patrick +256-772346867

The project has been reviewed and approved by the CSIRO Social Science Human Research Ethics Committee, Australia. The Chair of the institutional ethics committee of International Livestock Research Institute, Dr Delia Grace, has also reviewed ethical issues in the project. Dr Grace can be contacted on +254-20-422 3000.

Appendix 2: Pig health and farmer livelihoods: Participant consent

I confirm that:

- I have understood the explanation of the research as set out in the project information sheet
- I have had the opportunity to ask questions about the research and I am happy that my questions have been answered.
- I am happy to allow measurements and samples to be taken from my pigs.
- I am happy to answer the questions that the research team asks me. I know that if I do not want to answer any question I can say "I do not want to answer that."
- I know that my answers to questions and samples from my pigs will be stored and used in ways that keep my name and the exact location of my farm private.
- I understand that the research team will tell veterinary authorities and local leaders about what the whole research project finds out, but will not tell me personally.
- The researchers can use photographs of my farm or family to tell other people good, positive stories and will give me a copy of any photographs they use. For these photographs:

☐ I DO want the researchers to tell other people my name

☐ I DO NOT want the researchers to tell other people my name

Date……Village name ……Sub location/parish name…….

Participant name (1) …….Signature or mark ……

Participant name (2) …….Signature or mark ……..

Participant name (3) …….Signature or mark ……..

Telephone number (if available)……..

HH name, if different from participant name(s)……..

Enumerator and translator statement: I confirm that:

- I have fully explained the information that is included in this information sheet and consent form to the participant.
- I have encouraged the participant to ask questions about the project and I have answered the participant's questions to the best of my ability.
- I have not concealed any information about risks that may arise for participants and their pigs as a result of participation.

Enumerator Name..... Signature ..... Date …….

Translator Name Signature Date

Appendix 3: A study of pig movements and social networks and the potential risk of African swine fever outbreaks at the Kenya-Uganda border

Barcode:

SECTION 1: GENERAL INFORMATION

1.1 Name of Enumerator_____1.1.2 Date (DD/MM/) ___/___/12. 1.1.3 Language of administration____

1.1.4 District _____1.1.5 Division/County _____ 1.1.6 Location/sub county (LC3)_____

1.1.7 Sub-Location/parish (LC2)_____1.1.8 Village ((LC1)_____

1.1.9. GPS READING

Location of household: Latitude (N)_____ Longitude _____ (E) _____Altitude._____

SECTION 2: HOUSEHOLD INFORMATION

2.1 Details of household head and respondent

Respondent's Name	**Gender**	**Age (yrs)**	**Occupation**	**Level of education**	**Education of best educated HH member**	**Tribe**	**Position in HH**

2.2 If **Position in HH** is not HH head, then give details of HH head

HH head's Name	**Gender**	**Age (yrs)**	**Occupation**	**Tribe.**	**Level of education**

Gender	**Level of education/Training**	**Position in HH**	**Tribe**	**Occupation**
1=Male	1 =No formal education	1 = Husband/HH	1 = Kikuyu	1 = Farmer
2=Female	2 =Primary school	2 = Wife	2 = Luhya	2 = Civil servant/teacher
	3 =Secondary school (O'/A Level)	3 = Son	3 = Luo	3 = Business person
	4 =Technical/teacher's college	4 = Daughter	4 = Kisii 5 = Kalenjin	4 = Farm worker
	5 =University	5 = Farm worker	6=Samia 7= Iteso	5 = Retired
	6= Other	6 = Other (specify)	8=Japadhola 9=Banyole	6 = Casual labourer
			10=Bagwere	7=Other (Specify)
			11= Other (specify)_____	

SECTION 3: PIG HUSBANDARY/FARM CHARACTERISTICS

3.1. How many pigs does the Household have?

Category	**No. of grade /crosses**	**No. of local breeds**
Piglets (1-3 months)		
Weaners (>3 months)		
Sows (Pregnant or farrowed)		
Breeding boars		
Castrated boars		
Total		

3.2. Did you purchase any pigs in the last year? If yes please provide the following information on the number of pigs purchased.

Category	No. of pigs	Unit price
Piglets		
Weaners		
Sows		
Breeding boars		
Castrated boars		

3.4. How do you keep your pigs?

1= Tethered 2=Free Range 3=Housed 4=Other (specify)

3.5. Type of pig house? (Wall)

1=concrete 2= mud 3=wooden 4=other (specify)

3.6.Type of floor?

1=concrete 2= Earth 3=wooden 4=other (specify)

3.7. Are the piglets confined in the house all the time?

1=Yes 2=No

AGISTED CATEGORY (Pigs not on farm)

3.8.Do you have pigs in other households?

1=Yes **(Go to 3.13)** 2=No **(Go to 3.19)**

3.9.If Yes, How many pigs are currently not on the farm? _____

3.10. For the pigs given out, do you pay for looking after them? 1= Yes 2 = No

3.11. How do you pay for looking after your pigs? **1=Cash** **2= In-kind** **3= Others**

3.12. Please give information for the **last three** HH where you have given your pigs. (Agisted)

Pig category	Relationship	First and last name	Location (village name)	Contact (phone number)	Distance-1=<1km 2=1-5 km 3=5-10km 4=>10 km	Reason for giving away

Relationship options 1.=Neighbour 2.=Other farmer 3.=relative 4.=Friend 5=other

AGISTED CATEGORY (Pigs on farm)

3.13. Do you have pigs from other households?

1=Yes **(Go to 3.20)** 2=No **(Go to 3.21)**

3.14. If Yes, How many pigs are currently on the farm? _____

3.15. If no, have you ever had pigs brought to your farm? 1=Yes 2=No (Exit agisted pig on farm)

3.16. For the pigs brought, do you charge for looking after them? 1= Yes 2 = No

3.17. How do you charge for looking after the pigs? **1=Cash (Go to 3.24)** **2= In-kind (Go to 3.25)** **3= Others (Specify)**

3.18. Please give information for the **last three** HH where you have received pigs from.(Agisted)

Pig category	Relationship	First and last name	Location (village name)	Contact (phone number)	Distance-1=<1km 2=1-5 km 3=5-10km 4=>10 km	Reason for bringing

Relationship options 1.=Neighbour 2.=Other farmer 3.=relative 4.=Friend 5=other

SECTION 4: SOCIO-ECONOMIC CHARACTERISTICS

4.1.Does any member of the household have another job or source of income?

1=Yes 2=No

4.2. List the sources of income for the respondent and other household members?

Income source	**Amount per year (Shs)**
Wages/salaries	
Sale of livestock or livestock products **(go to 4.8)**	
Remittances from relatives	
Sale of crop produce**(go to 4.10)**	
Renting of land	
Trader/Business	
Government Pension	
Casual labour	
Other (specify)	

4.3.If Sale of livestock how do you sell? (Roadside, Local market, butchers, trader, home, others)

4.4.If local market, what is the name and average distance to local market (km)_____

4.5.If sale of produce, how do you sell? (Roadside, Local market, processor/trader, home, others)

4.6.If local market, what is the name and average distance to local market (km)_____

SECTION 5: PERSPECTIVES/EXPERIENCES

5.1. When did you first start keeping pigs on this farm? (Month/Year)_____

5.2. Is there a period when you stopped keeping pigs **1=Yes (go to 5.3)** **2=No (Go to 5.5)**

5.3. If yes, why had you stopped? _____

5.4. When was the last time you had pigs apart from the current one? (Month/Year) _____

5.5 Why do you keep pigs?
1= Home consumption 2= Income/cash 3= Culture 4= Hobby 5 Security/ mobile bank 6= Other (Specify)
5.6 What has your household used the income from pigs for?
1=Household use 2= purchase assets (land, tools, building) 3=Education/school fees 4=Health 5=Cost of HH events (weddings, funeral) 6=Purchase of other animals 7=Farm inputs 8=Other (Specify)_____
5.7 What gave your household the idea to start keeping pigs?
1=attended field day or workshop or baraza 2= saw pig-keeping by others 3=heard about pig-keeping by others 4=given a piglet 5=family has always had pigs 6=suggestion by extension officer or vet 5=Other (Specify)
5.8 Who influenced you to keep pigs?

1	Household member	**9.**	livestock development officer (includes NAADS)
2	Local leader	**10**	livestock health officer (includes DVO)
3	Neighbour	**11**	Farmer Organization or self help group
4	relative	**12**	Youth group
5	Friend	**13**	School
6	Other farmer	**14**	Church
7	Pig trader	**15**	NGO
8	Self	**16**	other

5.9. Why do you think it was a good idea?

1	Easy to look after	**4**		Returns are high with low inputs	8.Ease of sale
2	Viable/profitable Enterprise		**5**	They produce many piglets/Multiply faster	9.Other (Specify)
3	Require small space		**6**	Grow faster	

SECTION 6: PIG FEEDING

6.1. Who feeds the pigs? 1=Husband/HH 2= Wife 3=Daughter 4=Son 5Relative 6=Labourer 7=Collaborative

6.2. What do you feed your pigs on?

1=Commercial pig feeds (including pellets**)**
2=Home mixed feeds
3=Purchased maize/flour **(Ugali**)
4=By products from food processing
5=By products from brew
6=House hold food leftovers
7=Swill
8=Crop residues from farm
9=Grass

6.3 **If swill, how often do you buy? _____**

1= Not at all **2=**Daily **3=** Weekly **4=**Monthly

6.4. Where do you get swill from?

1=Hotel/restaurant 2=Institutions (e.g. hospitals) 3=Neighbours, other villagers 4=Other (specify)

6.5. Does the swill or house hold food leftovers ever contain pork products or pig offal and slaughter waste?

1=definitely no pork products	2= do not know	3= sometimes contain pork products	4=always contain pork products

6.6 Do you treat the swill in any way before feeding your pigs?

1=boil feed that may have pork products	2= treat feed that may contain pork products	3= make Ugali	4= mix various feed sources	5=Not treated

6.7. Can you give more information about one location where you get your swill (Repeat for up to three sources)

1=Name	2= village name	3= phone number	4= distance (<1km, 1-5km)

6.8. Do you give any other supplements to the pigs? (Vitamins, minerals) 1= Yes 2=No

6.9. What supplements do you give? List up to 4 options

1=Fish(*omena, mokene*)	2=Vitamins	3=Others (Specify)

6.10. How much do you spend on feed supplements per month? _____

6.11. Is there any time of the year when there is not enough food in the HH? (Mention months)_____

6.12. Is there any time of the year when there is not enough food for the pigs? (Mention months)_____

SECTION 7: PIG HEALTH

7.1. Do you treat these pigs for external parasites?

1=Yes **(go to 7.2)** 2=No **(go to 7.8)**

7.2. How do you treat them?

1=Mud baths/wallow	2=Vet	3=Self treatment	4=supervised dipping/spraying

7.3. How often?

1= Weekly	2=Fort nightly	3=Monthly	4=Every 3 months	5=Every 6 months

7.4. When was the last treat treatment (month/year) _____

7.5. Do you treat these pigs for internal parasites?

1= Yes 2=No

7.6. How often?

1=Once	2= Weekly	3=Fort nightly	4=Monthly	5=Every 3 months	6=Every 6 months

7.7 Have these pigs ever been sick in other ways? 1=Yes 2=No

7.8. The last time your pigs were sick, what symptoms did they have?

1=Diarrhoea	2=lack of appetite	3=dullness	4=swaying gait	5=skin flash	6=respiratory problems	7=Sudden death
8=Vomiting	9=Coughing	10=Shivering	11=Foaming at mouth			

7.9. Did you hear or see other farmers who had similar symptoms as your pigs? 1=Yes 2=No
7.10. Do you have a name for the disease the pigs had? _____
7.11. Did you go to anyone for help with the disease?
1=Yes 2=No
7.12. Who did you seek help from?

1=HH member	2=local leader	3=neighbour	4=relative	5=friend	6=other farmer	7=pig trader	8=livestock development officer includes (NAADS)
9=Livestock Development Officer includes DVO	10=NGO	11=Farmer organization/ self help group	12=Youth group	13=School	14=church	15=Private provider	16=other (specify

7.13. Who gave you the best help? (Please give contact details)

1=first and last name	2= village name	3= phone number	4= distance (<1km, 1-5km)

7.14 Did you report the disease to the veterinary authorities?
1=Yes (go to 7.19) 2=No (go to 8.1)
7.19. If you reported to vet authorities, how did you report?

1=mobile	2= physically	3= phone number	4= distance (<1km, 1-5km)

SECTION 8: CONSTRAINTS

8.1 Would you like to keep more pigs than you have now?
1=Yes 2=No
8.2. Do you face any constraints in keeping pigs?
1=Yes 2=No
8.3. If yes, what constraint do you face?

1=Feed constraints 2=Market issues (Go to 8.4.1) 3=Pig Health (Go to 8.4.2) 4= Lack of capital 5= other (Go to 8.5)_____

8.4. What feed constraints do you face?

1=poor quality feeds 2=Scarcity of feeds 3=High cost of feeds 4=Other (specify)

What market constraint do you face?

1=can't find pigs to buy 2=available pigs are of poor quality 3=no buyers for my pigs 4= Market disruptions (e.g. ASF Closures) 5=Transport of pigs to market 6=Poor market prices. 7=Other (specify)

8.6 What pig health constraints do you face?

1=frequent health treatment needed 2=cost of disease treatment 3=risk of pig deaths 4= ASF impact (mark only if mentioned specifically, then omit ASF awareness question) 5=other (specify)

8.7 What other constraints stop you from keeping more pigs?

1=time needed for pig care 2=lack of space 3=upgraded pig facility/housing needed 4= lack of financial capital 6= lack of access to credit 7= conflict with neighbours over pigs 8=other (specify)

8.8 Considering the time and money you spend on your pigs, what is the biggest risk to your pig investment?

1=Theft 2=Disease 3=Unreliable feed supply 4=Sabotage 5=ASF (if mentioned) 6=other (specify)

SECTION 9: ASF AWARENESS

9.1. Have you heard of a pig disease called ASF?

1=Yes 2=No **(Go to 10.1)**

9.2. When was the most recent ASF outbreak that you have heard about? (Month or year)_____

9.3 Where was the outbreak? (Village/District and Distance from your farm)_____

9.4. Have you ever had pigs that got sick or died from ASF?

1=Yes **(go to9.5)** 2=No**)**

9.5. How many ASF outbreaks have you had on your farm since you started keeping pigs? (E.g. 1, 2, 3-5, 5-10, more than 10)_____

9.6. When was the most recent ASF outbreak that you have had on your farm? (Month or year)_____

9.7. When there is an outbreak of ASF what do you do?

1=Reported to vet authorities	2=Reported to NGO	3=Reported to NAADS	4=Reported to private service provider
5= Self medicated	Slaughtered	7= Got advice from Agrovet	8 Never sought for help
9=Sold	10. Other (specify)		

9.8. Please provide the following information on the number of pig sold during the most recent ASF outbreak?

Category	No. of pigs	Unit price
Piglets		
Weaners		
Sows		
Boars		

9.9. How many of your pigs died from the recent ASF outbreak? _____

Category	Piglets	Weaners	Sows	Boars
No. of pigs				

9.10. How many of your pigs survived in the most recent outbreak? _____

9.11. How did you know about the most recent outbreak?

1=own pigs got sick or died 2= neighbours pigs got sick or died 3= Heard about outbreak from someone (got to ASF outbreak information) 4= others (specify)

9.12. Who did you hear from about the most recent outbreak?

1= household member 2=local leader = 3= neighbour 4=relative 5=friend 6=other farmer 7=pig trader 8=livestock development officer (includes NAADS) 9=livestock Health Officer (includes DVO) 10=NGO 11=Farmer organization or self help group 11=Youth group 12=School 13=Church 14=Private Service provider 15=Other

9.13=Has ASF affected your pig farming in other ways?

1=Yes 2=No

9.14 In what other ways has ASF affected your pig farming?

1=closure of pig market 2=-did not restock for some time 3=no pigs available for restocking 4=sold pigs early 5=good sales price due to pig scarcity after outbreak 6=other

SECTION 10: OUTPUTS FROM PIG FARMING

10.1. What do you get from pig farming?

1= Sale of mature pigs 2= Sale of piglets 3=Sale of pork 4=manure 5=biogas 6=other (Specify)

10.2. Please provide the following information on the number of pig sold during the last year?

Category	No. of pigs	Unit price
Piglets		
Weaners		
Sows		
Breeding boars		
Castrated boars		

10.4. Do you do anything with the manure from your pigs?

1=No, not collected nor used	2= No, collected/piled up but not used	3= Yes, collected and used on field	4= Yes, composited before used on field	5=Yes, biogas generation	6=Yes-Sold **(go to 10.5)**	7=Yes , other use specify

10.5. Do you eat pork in your household? 1= Yes **(Go to 10.9)** 2=No **(Go to 11.1)**

10.6. How often?

1=Never	2=Everyday	3=Often>once a week	4=regularly > Twice a month	5=Sometimes, once a month	6=Rarely, once/twice a year

10.7. Where do you usually get your pork from?

1=Home slaughter	2=Relative	3=Neighbour	4=Friend	5=Butcher	6=Restaurant/pork joint	7=other

SECTION 11: BIOSECURITY

11.1. Do you ever use disinfectant on your farm? 1=Yes (**Go to 11.2**) 2=No **(Go to 11.5)**

11.2. What type do you use? _____

11.3. When do you use disinfectants?

1=clean pig house	2=wash hands e.g. after animal handling	3=dead animal disposal	4=clean shoes of visitors to pig farm	5=other household use	6=other (specify)

11.4. How often?

1= Always	2=regularly	3=irregularly

11.5. Give reasons for not using disinfectants?

1= cash constraint **2=** I don't know how to use. **3=**I don't know what to use **4=**= I don't know that I need to use it **5=**Never heard about disinfectant

11.6. How often do you get visitors to your farm (including neighbours, relatives, friends, others)

1=most days	2= a few times each week	3= a few times each month	4=less than once a month	5= very rarely	6=never

SECTION 12: ADVICE AND TRUST

12.1. Where do you get information that is helpful for farming or for family and household issues? (Trust to give you this information)

1=radio	2=TV	3=news letters/books	4= Internet	5= household member	6=local leader
7=neighbour	8=relative	9=friend	10= other farmer	11=pig trader	12. livestock devpt officer (NAADS)
13. Livestock health officer (e.g. DVO)	14=Agricultural extension officer	15.=NGO	16= Farmer organization or self help group	17= youth group	18=Baraza

12.2. If you have problem on your farm, who would you trust to give you advice or help?

1=HH member	2=local leader	3=relative	4=friend	5= other farmer	6=pig trader
7=. livestock dev't officer (NAADS	8= Livestock health officer (e.g. DVO)	9= NGO	10= Farmer organization or self help group	11= youth group	12) school
13. Church	14= Agricultural extension officer	15=other			

12.3. Can you give us more information to help us find the person who you would trust for advice or help, so that we can interview them (allow options of adding more than one entry)

1=first and last name	2= village name	3= phone number	4= distance (<1km, 1-5km)

12.4. If you have a problem in pig-keeping, whom do you trust to give advice or help?

1=HH member	2=local leader	3=relative	4=friend	5= other farmer	6=pig trader
7=. livestock devpt officer (NAADS	8= Livestock health officer (e.g. DVO)	9= NGO	10= Farmer organization or self help group	11= youth group	12) school

12.5 Can you give us more information to help us find the person who you would trust for advice or help so that we can also interview them (allow options for adding more than one entry)

1=first and last name	2= village name	3= phone number	4= distance (<1km, 1-5km)

12.6 Are you or any other household member, a member of any farmer organization, community organization, saving and credit cooperatives, SACCOs? **1=Yes** **2=No**

12.7. If Yes which organization? _____

12.8 What benefits do you get from the organization? (Answer for each organization)

1=Saving scheme	2= Financial credit	3= information and advice	4=Purchase of food or farm input	5= marketing and sale of farm products	6= processing farm products

12.9. What impact has the organization had on your livelihood? **1=substantial** **2=Moderate** **3=little** **4= None**

12.10 Has any member ever obtained credit facilities to promote pig farming? **1=Yes** **2=No (Go to 12.13)**

12.11. Who obtained the credit? 1= Husband/HH 2=Wife 3=other

12.12 Where did you obtain the credit from? _____

12.13 What was the credit needs?

1=purchase pigs	2= purchase feeds	3= vet services	4= other

12.14. If no credit was obtained, why not?

1=credit required but did not get	2= credit not available	3= credit too costly	4= lack of collateral	5= not aware	6= Fear of being unable to pay
7= never thought of it	8=do not need credit	9=other			

SECTION 13: HOUSEHOLD WEALTH INDICATORS

13.1. Financial Capital. What other livestock do you keep?

Type of animal	**Young animals**		**Adults**		Give the 3 most important reasons why you keep livestock*			Average annual income
	Number	Price per animal	Number	Price per animal				
Cattle								
Goats								
Sheep								
Poultry								
Rabbits								
Donkeys								
Other Livestock								

Reasons for keeping animals

1 = Meat for sale	**2** = Meat for HH consumption	**3=** Milk for sale	**4** = Milk for HH consumption	**5=**Bulls for service	**6** = Traction **7=** Income
8 = To pay dowry	**9** =Eggs for home consumption	**10** = Eggs for sale	**11** = Manure	**12** = Boar for contractual breeding	**13=**other (Specify

13.2 Apart from the pigs that you own now, have you owned other pigs and/ piglets in the past year? (Sold off or died)

1=Yes (go to 14.4) 2=No (go to 14.2 & 14.3)

13.3. Why haven't you kept pigs during this period?

1=New to pig-keeping	**2=**I've not sold within the last year	**3=**No deaths in the past year
4=Recently restocked after ASF outbreak	**5=**Recently restocked after break	

13.4. If No, when did you last/sale/give away/lose a pig? _____

13.5. If yes, how many? _____

Go to PAST PIGS (Pigs that are no longer on the farm)

PAST PIGS (Pigs that are no longer on the farm. Include the ones that died)

14.5. HHID Barcode_____

14.6. Pig Breed_____

14.7. Pig Category_____

14.8. When did you get that pig? (Month/year)_____

14.9. When did you dispose of this pig (s)_____

14.10. How did you acquire this pig?

1=born in the HH **(Go to 14.13)**	2=purchase	3=gift (payment for boar service)	4=gift (via a rural development project or NAADs)	5=gift (other specify)	5=agistment	6=on loan

14.11. Who did you get this pig from? (Relationship)

1=local leader	2=neighbour	3=relative	4=friend	5=other farmer	6=pig trader	7=livestock development officer (includes NAADS)	8=NGO
9=Farmer organization or self help group						10=other (School, church, youth group)	

14.12. Can you give us more information to help find the person you got this pig from, so that we can also interview them about pig-keeping?

First and last name	Location (village name)	Contact (phone number)	Distance-1=<1km 2=1-5 km 3=5-10km 4=>10 km

14.13. What happened to this pig

Options	**Who (relation)**	**Pig sale price**

Options:

1=sold (**Go to 14.14)** **2**=Gift (in exchange for sow service) (**Go to 14.14)** **3**=Gift (gave it away for other reasons) (**Go to 14.14)** **4**=Slaughtered at home (**Go to 14.16)** **5**=Death (**Go to 14.19)** **6**=Other (Specify)

Relationship

1=local **2**=neighbour **3**=relative **4**=friend **5**=other **6**=pig **7**=livestock **8**=NGO **9**=Farmer organization **10**=other

leader	farmer	trader	development officer (includes NAADS)	or self help group	(School, church, youth group)

14.14. How many were sold or given away as gifts? **(FOR PIGLETS ONLY**)_____

14.15. If sold or given as a gift, give the following information on recipient.(**FOR PIGLETS GIVE THE FARTHEST KNOWN)**

First and last name	Location (village name)	Contact (phone number)	Distance-1=<1km 2=1-5 km 3=5-10km 4=>10 km	Reasons for sale

<u>Reason for sale</u>:

1=needed money at that time **2=** the right size for sale **3=**trader came to buy pig **4=**disease outbreak or rumour of outbreak **5=**not enough food for the pigs 6=other

14.16. What is the nearest market? _____

14.17. If slaughtered at home, why did you slaughter? _____

14.18. What did you use the pig for after you slaughtered it?

1=family ate the meat 2=meat given to other people 3=meat sold 4=other

14.19. If meat sold or given, please give the information below

Name of the furthest village meat sold	Distance-**1**=<1km **2=**1-5 km **3=**5-10km **4**=>10 km

14.20. If the pig died, what were the symptoms before death?

1=sudden death 2=diarrhoea 3=dullness 4=swaying gait 5=skin flushing 6=lack of appetite 7=Coughing 8=Vomiting

14.21. Did you see pigs in other households with similar symptoms as your pig?

1=Yes **2=**No

14.22. Did you hear about pigs belonging to other people that had similar symptoms?

1=Yes 2=No

14.23. Do you have a name for the disease the pigs had? _____

14.24. Did you go to anyone for help about the disease?

1=Yes (**Go to 14.25)** 2=No (**Go to 14.29)**

14.25. Who did you seek help from?

1=HH member	2=local leader	3=neighbour	4=relative	5=friend	6=other farmer	7=pig trader	8=livestock dev't officer includes NAADs	9=livestock health officer includes DVO	10.NGO
11. Farmer organization or self help group	12=youth group	13=private service provider	14.others (church)						

14.26. Who gave you the best help?

First and last name	Location (village name)	Contact (phone number)	Distance-**1=**<1km **2=**1-5 km **3=**5-10km **4=**>10 km

14.27. Did you report the disease to the veterinary authorities'?

1= Yes 2=No

14.28. If you reported to the veterinary authorities, how did you report?

1=mobile phone 2= physically visited 3=asked someone else to tell the vet authorities? 4=others

14.29. When your pigs died, what did you do to the dead pigs?

1=buried deep, disinfected	2=buried, but not necessarily deep or disinfected	3= burnt	4=fed to pigs	5=fed to other animals (not pigs)	6=gave to someone else to dispose of	7=other (specify)

CURRENT PIG DATA FORM

1.1 Ear Tag ID (Similar to sample ID whole blood, serum and faeces) _____

1.2 Has this pig been sick since the last visit? 1=Yes 2=No

1.3. If Yes, What were the symptoms?

1=Diarrhoea	2=lack of appetite	3=dullness	4=swaying gait	5=skin flash	6=respiratory problems	7=Vomiting
8=Coughing	9=Shivering	10=Foaming at mouth	11. Wounds			

1.4. Does this pig belong to this household? (Hide if sampled in last visit) **1=**No **2=**Yes

1.5. Where did you get this pig from?

1=neighbour	2=relative	3=Other farmer	4=pig trader	5=NAADs	6=NGO
7=Farmer	8=Friend	9=Youth	10. Born in the		

organization or self help group		group	HH (go to pig category)		

1.6. How did you get this pig?

1=Purchased	2=Gift (payment for boar service	3=Gift (via rural development project or NAADS)	4=Gift (other specify)	5 = loan

1.7. When did you acquire this pig? Month/year_____

1.8. Contact or pig source (can you give us more information to help us find the person you got this pig from, so that we can also interview them about pig-keeping?

First and last name	Location (village name)	Contact (phone number)	Distance-1=<1km 2=1-5 km 3=5-10km 4=>10 km

1.9. Pig category

1=Weaner (> 3 months)	2=Sow	3=Entire boar	4=Castrated boar	5=Piglet (If mother not present)

SOW CATEGORY

1.10. If the pig category is sow, then indicate the sow status

1=Not Pregnant& not Farrowing	2=Pregnant (1st time)	3= Pregnant (>1)	4=Farrowing

1.11. Do you own the boar that serviced your sow? 1=Yes (**end on sow category**) 2=No

1.12. If No, what is the boar' owner's name?

First and last name	Location (village name)	Contact (phone number)	Distance-**1=**<1km **2=**1-5 km **3=**5-10km **4=**>10 km

1.13. What relationship do you have with this person?

1	Neighbour	2	Other farmer	3	relative	4	Friend

5	Pig trader	6	NAADs	7.	NGO	8	other

1.14. Where did the sow get serviced?

1=This farm (own pig)	2=This farm (other HH pigs)	3=Boar owners farm	4=Do not know

1=one piglet from litter	2=cash	3=other

1.15.What did/will you pay for service?

1.16. If cash, how much did you pay for the service? Shs _____

BOAR CATEGORY

1.17. Has this boar been taken to service other household's sows since the last visit?

1=Yes 2=No **(Go to 1.55)**

1.18. If yes, how many other households has this pig been taken to service?

1=0-3	2=4-6	3=7-9	4=10-15	5=>15

1.19. Where did the service happen? Please give at least three of the last households

Relationship	First and last name	Location (village name)	Contact (phone number)	Distance-1=<1km 2=1-5 km 3=5-10km 4=>10 km

Relationship 1.Neighbour 2. Other farmer 3.Relative 4.Friend 5.other

1.20. What payment arrangements did you make for the last 3 services?

	HH1	HH2	HH3
Mode of payment			

1=one piglet from the litter **2= cash payment** **3=No payment** **4=any other form of payment**

1.21. Did the owner of the sow make the payment?

HH1	HH2	HH3

1=Yes 2=No (no reason given) 3=No, pig not yet farrowed. 4=No, (e.g. piglets died)

1.22. Have other sows been brought here for servicing since the last visit?

1=Yes 2=No **(end of boar category)**

1.23. If yes, how many sows from other HHs have been brought for service?

1=0-3	2=4-6	3=7-9	4=10-15	5=>15

1.24. Please give at least three of the last households (excluding those currently on the farm)

Relationship	First and last name	Location (village name)	Contact (phone number)	Distance-1=<1km 2=1-5 km 3=5-10km 4=>10 km

Relationship **1. Neighbour** **2. Other farmer** **3. Relative** **4. Friend** **5.other**

1.25. What payment arrangements did you make for the last 3 services?

	HH1	**HH2**	**HH3**
Mode of payment			

1= one piglet from the litter **2= cash payment** **3=No payment** **4= Other form of payment**

1.26. Did the owner of the sow make the payment?

HH1	HH2	HH3

1=Yes 2=No (no reason given) 3=No, pig not yet farrowed. 4=No, (e.g. piglets died)

AGISTED PIG (ON FARM)

1.27 Pig Category

1=Weaner	2=Sow	3=Entire boar	4=Castrated boar	5=Piglet

1.28. Who is the pig owner? (Relationship)

Relationship	First and last name	Location (village name)	Contact (phone number)	Distance-1=<1km 2=1-5 km 3=5-10km 4=>10 km

Relationship 1.=Neighbour 2.=Other farmer 3.=relative 4.=Friend 5.=Pig trader 6.=NAADs 7.=NGO 6=other

1.29. How long has the pig been here? _____

< 1 week	**1-2 weeks**	**2. 2-4 weeks**	**3.>4 weeks**

1.30. Why was the pig brought here?

1=to access feed	2.=To service or be serviced	3.=Protect crops on farm	4.=Clearing weeds or regrowth	5.=Rear and share piglets	6=other

Appendix 4: Extended Social Networks Questionnaire

SECTION 1: GENERAL INFORMATION

1.1 Name of Enumerator	**1.1.2** Date (DD/MM/) __/___ **/13**	**1.1.3** Language of administration	**1.1.4** District
1.1.5 Division/County	**1.1.6** Location/sub county (LC3)	**1.1.7** Sub-Location/parish (LC2)	**1.1.8** Village (LC1)

Respondent's Name	**Gender**	**Age (yrs)**	**Level of education**	**Tribe**	**Role/position in Business**

EXPERIENCE IN THE PIG ENTERPRISE

2. How long have been engaged in the pig business?
3. Do you buy the pigs for?

Slaughter	**Sale**	**Keeping/growing/finishing**

4. Which categories of pigs do you trade in?

Piglet	**weaner**	**Adult**

5. How do you get information on how/where to get pigs?
6. What do you look for when deciding to purchase pigs? (Health status, legal requirements, distance, accessibility)
7. How do farmers make contact with you? Eg phone, face to face etc
8. What is the availability of pigs within a calendar year?(use months, seasons or events).
    a. What do you think is the reason for this distribution?

9. How many pigs have you bought in the past month?
10. Has this been a busy or a quiet month?

SOURCE OF PIGS

11. Do you always buy from the same villages?
12. Over the past year, which villages did you buy from? (**USE TABLE BELOW**)

Village Name	**% or proportion of purchases in past year**	**Approx Distance**	**Approx Direction**	**Type of transport. Cost incurred and how much**	**#1 Other trader who operates here (Name of trader & Village where trader is based)**	**#1 Other trader who operates here (Name of trader & Village where trader is based**

13. **For butchers**, which slaughter slab(s) do you use?

Quantify which slabs are used

Private or public slab	**If private, name of owner**	**Location of slab**	**Proportion of pigs slaughtered from the slab per month**	**Cost of slab use**	**#1 Other trader who operates here (Trader name & Village name where trader is based)**	**#2 Other trader who operates here (Trader name & village name where trader is based)**

14. Any other costs involved in purchase of pigs that we have not mentioned?
15.

Item	Cost (KSh) per pig
Transport to and from slab	
Inspection	
Water	
Firewood	
Syringe	
Razor	
Permit for meat transport	
Hired labour for selling pork	
Soap	
Total cost	

16. Do you have any dealings with animal health service providers? (details)
17. Do you have any dealings with other people who supply inputs to your business?

TYPE OF SUPPLIERS

18. Are the people you buy from repeat suppliers?. (Quantify % repeat suppliers.
    a. If you think about your last 10 suppliers, how many were repeat suppliers?
    -
    - Is this pattern typical?
19. Are your suppliers relatives? (Quantify % relatives. what proportion of suppliers are relatives?)
    - If you think about your last 10 suppliers, how many were relatives?
    - How many were other people that you know?
    - Is this pattern typical?

20. When you buy pigs, do you buy from men or women? (i.e. what gender of person you negotiate with and make agreement about the purchase, and pay the money to).

- what proportion are men?
- Is this pattern typical?
- When men are selling the pigs, are women also involved in the negotiations/sale?
- When women are selling the pigs, are men also involved in the negotiations/sale?

For live pigs, whom do you sell to? For butchers, where do your customers come from?

% or proportion of customers in past year	Village Name	Approximate Distance

21. Are the people you sell to repeat customers. Quantify % repeat customers.
    - What proportion are repeat customers/people who have bought before?
    - If you think about your last 10 customers, how many were repeat customers?
    - Is this pattern typical?
22. Are your customers relatives?
    - What proportion of customers are relatives?
    - If you think about your last 10 customers, how many were relatives?
    - What proportion are other people that you know?
    - Is this pattern typical?
23. When you sell pigs/pig meat, do you sell to men or women? Quantify % gender.
    - What proportion are men?
    - If you think about the last 10 pigs/meat products you sold, how many times did you sell to a man?
    - Is this pattern typical?
    - When men are buying pig meat /pigs, are women also involved in the purchase?
    - When women are buying pig meat /pigs, are men also involved in the purchase?

24. How do you determine the price you pay for a pig?
25. How do you work out pig weight
26. What price do you sell meat?
27. Does the price of meat fluctuate/vary?
28. If the price fluctuates, what determines price?
29. Do you sell all parts of a pig eg leg, ribs etc at the same price?
30. What mode do you use to pay the farmers? (**Mpesa? Exchange cash, etc**)

BUSINESS CHALLENGES

31. What challenges do you face in your pig business?
32. What is the biggest risk to investment in your business?
33. Are there other issues that have negative impact on your pig business?

(Prompt: If they don't mention disease) Do you know of diseases that affect your pig business?

34. What happens when there is an ASF in this area? How does it affect your business
    - During the outbreak?
    - After the outbreak?
35. **LAST ASF OUTBREAK**
    a. How many ASF outbreaks have affected you in the last year?
    a. When was the last outbreak? (Year and month)
    b. Which village did the outbreak start from? (Village name and direction(near a school, hospital etc))
    c. What do you think/hear was the cause of the outbreak?
    d. Which other villages did the disease spread to?
    e. What factors may have caused the disease to spread to these other villages?
    f. Who do you hear about the outbreak from?
    g. What did you do when you heard about the outbreak?
    h. Is that typical of what you would do during an outbreak of ASF?

36. Do farmers try to sell sick pigs?
37. Do butchers buy?
38. Can you recognize a pig that has ASF?
39. How do you recognize?
40. Have any problems arisen for you in keeping your business going during ASF outbreaks?

OTHER ISSUES AND SUPPORT FOR BUSINESS

41. What are the legal requirements for your business?

License	**Cost**		**cost**
Transport license requirements		Inspection of pork by a meat inspector	
Certificate of good health by the person serving clients		Uniform and gumboots	
County license		Meat box license	
Weights and measures license		Inspection of premises by public health officers	
Health officers license to sell pork		Trade license	

42. Do you experience any problems complying with these requirements?
43. Who has given you help with your business?(details what? Why?)
44. Who do you trust most to give you advice for your business? (Details)
45. Have you ever accessed credit for your business? (Details)
46. Do you belong to any organizations for business owners or pig producers? (details)

Appendix 5: Extended Social Networks Questionnaire for Animal Health Service Providers

SECTION 1: GENERAL INFORMATION

1.1 Name of Enumerator	**1.1.2** Date (DD/MM/) **__/___ /13**	**1.1.3** Language of administration	**1.1.4** District
1.1.5 Division/County	**1.1.6** Location/sub county (LC3)	**1.1.7** Sub-Location/parish (LC2)	**1.1.8** Village (LC1)

Respondent's Name	Gender	Age (yrs)	Level of education	Organization	Position in organization

EXPERIENCE IN THE PIG ENTERPRISE

2. How long have been working in this organization?
3. What services do you offer to pig farmers?
4. How do you get information about a pig farmer who needs help?
5. How do farmers make contact with you? Eg phone, face to face etc
6. Is contact from men and women equally, or more from one or other gender
7. When asking them about the contact they have with farmers, male/female balance, could you also be prepared to tell them about what we have found about gender responsibilities in pig-keeping

Do you have any mechanisms or thoughts or ideas about improving service to women in particular?

8. What is the work load of pigs' services within a calendar year?(Use months, seasons or events).
   a. What do you think is the reason for this distribution?
9. How many farmers did you attend to in the past year?

Area Service Provider covers

10. Which villages do you serve the most?
11. Over the past year, which villages did you serve? (**USE TABLE BELOW**)
12. Which other service providers serve the same village?

% or proportion of villages served in past year	**Village Name**	**Approx Distance**	**Approx Direction**	**Transport. Cost incurred and how much**	**#1 Other service provider who operates here (Name and organization, Location)**	**#1 Other service provider who operates here (Name and organization, Location)**

13. Do you charge for the services rendered?
14. How much?

Item	**Cost (KSh) per pig**
Transport	
Professional fee	
Other	

CHALLENGES

15. What challenges do you face in your work?

16. What disease do you encounter during your work?
(Prompt ASF if they don't mention)

17. LAST ASF OUTBREAK

b. How many rumours of ASF outbreaks did you get in the last year?
c. How many were confirmed?
d. How do you establish confirmation of an ASF outbreak
e. When was the last outbreak? (Year and month)
f. Which village did the outbreak start from? (Village name and direction(near a school, hospital etc))
g. What do you think/hear was the cause of the outbreak?
h. Which other villages did the disease spread to?
a. What factors may have caused the disease to spread to these other villages?
i. Who do you hear about the outbreak from?
j. What did you do when you heard about the outbreak?
k. Was what you did in relation to this outbreak typical to what you would do in other outbreaks you have experienced?

18. In your experience, who do pig owners seek for help when they have a problem with their pigs?
19. In your view, what are the main constraints, and main risks to pig production?
20. What are the key practices, changes, new technologies or actions that could contribute to reducing;
    a. The number of outbreaks,
    b. Size/spread of outbreaks.
    c. Who needs to be involved in designing and implementing these changes?
    d. What can they (People involved in designing and implementing changes) do to contribute to reducing ASF outbreaks?
    e. What help/support/other people's actions would they require?
21. In your view, what is the potential for increased pig production in your work area especially in relation to other animal industries?

In your view, what is the future of pig production?

Appendix 6: Ethical approval

From: Commonwealth Scientific and Industrial Research Organization (CSIRO) - Social Science Human Research Ethics Committee (CSSHREC)

Sent: Monday, 5 September 2011 10:50 AM

To: Davies, Jocelyn (CES, Alice Springs DKP) Cc:r.bishop@cgiar.org'; Prideaux, Chris (LI, St. Lucia); Bruce, Caroline (CES, Dutton Park); Pengelly, Bruce (CES, Dutton Park) Subject: Ethics Clearance 059/11 Understanding the epidemiology of African swine fever (ASF) as a prerequisite for mitigation of disease impact on pig-keeping in east Africa

Dear Jocelyn and the Project Team,

Thank you for your ethics application059/11 "Understanding the epidemiology of African swine fever (ASF) as a prerequisite for mitigation of disease impact on pig-keeping in east Africa" that you recently submitted.

The CSIRO Social Science Human Research Ethics Committee reviewed your application at its meeting on the 29th August 2011. Your project has been assessed against the requirements set out in the National Statement (2007) and I am pleased to advise that based on the information you provided the Committee considered your project approved. In reviewing your submission, the Committee raised the following issue and would like to ask you for your response.

While the submission highlighted conceivable benefits and risks, the Committee expressed an interest in learning more about the magnitude and distribution of sentinel pigs. In particular, whether this gesture could have potential pernicious consequences for the local community. The

Committee seeks to understand how sentinel pig owners will be chosen and if the research team anticipates potential conflict associated with the (perceived or otherwise) unequal distribution of benefits. How might these risks be managed?

In addition, the Committee would like to remind the Project team to establish and maintain a system of recording individual consent in field research records. The Committee would also like to review the final version of the information sheets and consent forms to be used once these have been finalized.

Ethical clearance has been granted for the project for the following period 05/09/11 to31/10/13.As the project is being conducted over an extended timeframe you will be required to submit annual progress reports and a final report upon the project's completion. Templates for these reports will be forwarded to you in due course.

Please feel free to contact the ethics secretariat if you would like to discuss or clarify any of this feedback.

In granting ethical clearance you are reminded of the importance of adhering to the requirements of the National Statement at all times during the life of the project. Should any adverse events occur to participants during or resulting from the research or any ethically relevant variations be needed regarding the project's implementation or completion you are required to notify us immediately for further advice or amended clearance.

On behalf of the Committee I wish you all the best with your research.

Kind Regards

Lucy

Dr Lucy Carter

Acting Manager, Social Responsibility and Ethics CSIRO Ecosystem Sciences EcoSciences Precinct, 41 Boggo Rd, Dutton Park, QLD 4102, Australia Ph: +61-7-3833 5693 M: +61-409-441-055 Fax: +61-7-3833 5505 Web: http://www.ces.csiro.au/

Appendix 7: Uganda Villages where Households reported heard or had suspected ASF outbreaks

Month and Year	Villages
Jan-11	Nebolola B, Nebolola A, Buhehe, Bwolia, Bwani, Bulekya, Buteba, Okame Amagoro, Aterait, Rudacho, Busambo, Buhumwa
Feb-11	Bukani, Busia, Sophia, Bunyukhe, Northern Uganda, Alupe, Asinge
Apr-11	Nebolola B, Paloto A
May-11	Bwolia A, Bwani, Busamba
Jun-11	Bukani, Sophia, Mawero, Bulekya, Teso Region
Jul-11	Khasyule, Bulamuli, Buduma, Bulekya
Aug-11	Bukani, Lumino, Bwolia A, Mbale, Bunyukhe, Aterait, Tororo
Sep-11	Buhehe, Bukani
Oct-11	Hasyule A, Bukani, Bunyukhe, Akobwait, Kadanya, Poniara
Nov-11	Khasyule, Bwolia A, Bunyukhe, Bulekya, Popanyi, Kadanya, Bukani
Dec-11	Nebolola B, Tororo, Bukani, Bunyukhe, Bulekya, Buhumwa, Namungodi, Alupe, Kalait, Osere B
Jan-12	Bunyide, Nahayaka, Sophia, Bwani, Bunyukhe, Busia Uganda, Alupe, Poniara
Feb-12	Nebolola B, Busia, Bulekya, Ojamii, Okame Amagoro, Paloto A, Nangongera, Ojamii
Mar-12	Nebolola B, Lumino, Bukani, Buhehe, Bwolia, Buhumwa, Alupe, Bwarira
Apr-12	Masaba, Bukani, Bwani, Bumunji, Alupe, Okame Amagoro, Iyolwa, Poniara, Lwala, Magola, Busia
May-12	Bunyide, Bwani, Bwalila, Busiho, Bukhumwa, Sukuda, Buhehe, Kalait, Butebe, Paloto

Month and Year	Villages
Jun-12	Bukani, Bwolia A, Mukhumwa, Alupe, Kadanya, Magola, Sophia, Bunyukhe
Jul-12	Buhehe, Busia Uganda, Buhumwa, Okame Amagoro, Mile Nane
Aug-12	Lumino, Bwolia A, Nanjeho, Sophia, Buhumwa, Masinya, Alomodoi Kenya, Okame Amagoro, Adanya, Kangura East, Poniara, Nyemera A, Poyem B, Atanga
Sep-12	Bukani, Lumino, Sophia, Bwolia A, Alupe, Samia Uganda, Okame Amagoro, Alomodoi Kenya, Kadanya, Kalait, Kadanya, Osere A, Magola, Poniara, Paloto A, Papada, Magola Cell, Poyem A, Poyem, Paloto B, Bwolia B, Osere A, Poyem
Oct-12	Nebolola B, Bunyide, Bwani, Banda, Bunyukhe, Bulekya, Achaba Market, Okame Amagoro, Kadanya, Aterait, Aterait, Namboko, Kangura East, Osere A, Magola, Papada, Nyemera, Auyo Tororo, Poyem A, Bwalia A, Atanga, Osere A, Aterait, Poyawomeri, Poyem A, Pajwenda, Nyemera A
Nov-12	Kadanya, Akouketom, Kalait, Aterait, Erot Ketome, Bugisu, Kangura East, Kangura Central, Osere, Osere B, Awesit, Mella, Poniara, Mella, Poyem A, Bumanda, Bunyukhe, Apokor, Nyemera A, Poyem A, Opokongo, Aterait, Ochoto, Kalait, Morukebu B, Osere A, Magola, Poyem, Nyemera, Poyem A
Dec-12	Osere A

Appendix 8: Kenyan Villages where Households reported heard or had suspected ASF outbreaks

Month and Year	Villages
Jan-11	Samma, Kongurakoli, Kajei, Buremia, Rudacho, Sigalame, Busijo, Buradi, Sidonge, Bwakama, Butemula, Sigomere, Mukhweso, Uganda, Ojamong, Adongosi, Mundere, Bwakama, Igero
Feb-11	Abileng, Bwakama, Busijo, Buradi, Butemula, Aget
Mar-11	Apokor A
Apr-11	Onyunyur, Bwakama, Rudacho, Bumayenga, Mukhweso, Aget
May-11	Abileng, Amoni, Bwakama
Jun-11	Mundere, Sidonge, Igero, Magola, Aget
Jul-11	Bwakama, Mundagaywa, Mukhweso
Aug-11	Busonga, Sio port, Mundagaywa, Gonga, Mangula, Sigomere, Mukhweso, Buchabi, Samia
Sep-11	Uganda
Oct-11	Mugonga, Buyuha, Mundika

Month and Year	Villages
Nov-11	Okook, Apokor, Moding, Buradi
Dec-11	Erot Ketome, Katanyu, Sibinga, Busijo, Butemula, Sigomere, Alupe
Jan-12	Samma, Abileng, Kasinge, Luhonge, Erot Ketome, Marachi, Uganda, Butemula, Igero, Aget
Feb-12	Majanji, Sidonge
Mar-12	Samma, Kasinge, Kongurakol, Apokor A, Atapar, Totokakile, Onyunyur, Bwakama, Mundagaywa, Butemula, Mukhweso
Apr-12	Okook, Angurai, Kasinge, Adumai, Apokor A, Adumai, Dip Area, Katanyu, Magunga, Butemula, Sidonge
May-12	Amairo, Samma, Okuruk, Samma, Apokor, Erot Ketome, Apokor, Kajei, Kamolo, Bwakama, Rudacho, Busijo, Mango, Bumala
Jun-12	Okwata, Samma, Okook, Abileng, Moding, Kongurakoli, Moding, Kamolo, Totokakile, Amoni, Katanyu, Busonga, Uganda, Butemula, Alomodoi,
Jul-12	Amukurat, Abileng, Kongurakoli, Moding, Apokor A, Onyunyuri, Amukura, Dip Area, Atapara, Amoni, Ngamba, Kamolo, Malakisi, Amukura, Akiriamasi, Onyunyur B, Totokakile, Bwakama, Mundagaywa, Namasali, Sigomere, Aget, Kajei, Ajonai, Amoni
Aug-12	Nasimbo, Totokakile, Katanyu
Sep-12	Moding, Angorom

Appendix 9: Villages where traders in the study region reported had suspected ASF outbreaks

Month and Year	Villages
Aug-11	Uganda, Bukhwambo, Buloma, Sidonge
Nov-11	Bukoma, Sirimba, Nambengele, Mudembi, Budalangi
Mar-12	Ng'elecham, Okiludu, Alomodoi
Jun-12	Bulemia, Sisenye, Bwakama
Jul-12	Okame Abochet, Okame Amagoro
Aug-12	Lumuri (Uganda), Sigalame, Bumburi
Sep-12	Okook, Osuret, Odioi, Akiriamas
Jan-13	Buradi, Sidonge Uganda
Feb-13	Amerikwai, Bukalama, Adungosi, Lumino, Khasyule, Buhehe
Mar-13	Amoni

Month and Year	Villages
May 2013	Buyende, Mukhweso, Bululu, Amagoro, Paratere, Okwata, Kokoi, Akites, Busoga, Busia town, Bulula, Ganjala, Budimbidi, Nabiyonga Mulanda, Poniara, Bajwenda, Mukhweso, Buyende, Masafu, Masinya
Jun-13	Moding, Kasinge, Bunyadeti, Buhehe, Mang'ombe
July 2013	Osere B, Ochoto, Kalait, Manafa, Auyo, Bumanda, Pabone, Nyamulinde, Port, Poyem
Aug-13	Kona Zone, Amini, Mella, Apokor, Poyem B, Nagurisel, Bumanda, Auyo, Poyem A, Bunyadeti, Magola, Poniara, Posuna, Pokach

Appendix 10: Pig health and farmer livelihoods. Information for Farmers about Follow up study

Invitation to participate

Thank you again for your help with our research. We explained our research last time the team talked to you. To remind you, we are doing a research project to understand pig-keeping by farmers in your area and how farmers' livelihoods are affected by diseases that make pigs sick. Now we would like to talk to you about the second part of the study, and ask you if you want to participate.

We have selected some of the young pigs that we sampled in your village when we visited here before. One of your pigs was selected. We want to buy that young pig and leave it in your care, and take more samples from that pig in 3 months and 6 months time. When we come back, we will also want to ask you some more questions about your farm, livelihood and pig-keeping. We are also buying some other young pigs in this village but we are not buying every young pig. We

chose the young pigs that we want to buy fairly, so that every farm with a young pig had an equal chance of being selected.

Your consent to participate

You do not have to agree to participate in this second part of our research. You can say 'No' now, or you can say 'No' after you understand more about this part of the research. We will not talk to any other people about your decision. If you do agree to participate we will ask you to sign a written agreement to sell us the pig and take part in the second part of the research.

What it means to participate in the second part of the research

If you agree, we will buy your young pig. But we want you to continue to look after the pig for the next 6 months. We want you to treat this pig in the same way as you would treat it if it had not been purchased by the project team and in the same way that you treat other pigs that age, with the same kind of food, housing, health treatments etc. It is OK for you to make some changes to how you look after or feed your pigs as long as you make the same kind of changes for all your pigs, not just for the pig we have bought.

We will come back after 3 months and after 6 months to take blood and faecal samples from the pig, measure the pig and also your other pigs, in the same way as last time we examined your pigs. The reason for doing this is to find out how the health and size of the young pig changes over 6 months. We are buying the young pig in advance so that you do not sell it to someone else.

When we come back, we will also ask you some of the same questions we asked you previously, to find out if anything has changed in how you keep your pigs and the health of your pigs. We will also want to talk to you about what you think about the messages on biosecurity calendar that we gave you last time, and about other ideas or problems you might have about pig-keeping. As

well, we want to ask you about your farm and how pigs fit into food growing, income and expenses of your farm. Each visit will take about 2 hours. We would like you to answer all the questions we ask. But, if there is a question that you do not want to answer, you can say “I do not want to answer that’. If there is a question that you do not know how to answer, you can say “I don’t know”.

The last thing is that we would like you to keep some records, such as what you spend on your pigs for food and healthcare. When we come back in 3 months time and 6 months time, we will ask you about these things. If you agree to participate in this second part of the research we will work out with you a good way to keep these records.

Buying your pig

We will ---------- to buy your pig. You can choose to be paid in full at the end of 6 months or to be paid one third today, and one third on each of our next two visits.

If the pig dies in the next 6 months, you must contact us so that we can do a post-mortem examination. If you do this, we will still pay you the full KSh. 6000. If the pig is lost or stolen and is not here when we return in 3 and 6 months time, we will pay you a lesser amount.

After 6 months, we may take the pig with us for slaughter and post mortem testing. If we do not need to do this, then we may give the pig back to you and you can then sell it if you wish. If the pig is a sow and has piglets during the 6 months, you can keep the piglets.

We will keep your information private

The information you provide to us and the samples we take will be de-identified so that they are anonymous. This means that we will not keep your name with the information and samples. We will mark the information and samples with a barcode instead of your name.

We will store the samples from your pigs in cold storage. We will store the information you give us on computers. Only members of the research team will know the password to access this information.

When we use your answers to our questions in other parts of our research, we will not tell other people that you are the person who gave us this information. When we use the information about you or your pigs in our research reports, we will not use your name or the exact location of your farm. This means that people who read our research reports will not know if you participated or not, and what we found out about the health of your pigs. Other researchers may ask to do further tests on the samples we take from your pigs. Or they may ask to look at information that you and other participants provided. These researchers will not be able to find out your name from the samples or information.

Organizations involved in this research

This research project is funded by the Australian Government through AusAid, which is the Australian organization that provides aid to other countries. The overall aim of the funding is to help people in Africa with problems that affect the way that they grow food and trade food. This project is being undertaken by researchers from BecA-ILRI (Biosciences central and eastern Africa and the International Livestock Research Institute) with the Australian research organization CSIRO (Commonwealth Scientific and Industrial Research Organization).

Benefits and risks to participants

We are doing this research to help understand how to stop pig diseases and improve livelihoods of people who keep pigs or trade in pigs. These are big and complicated problems. This research will not provide all the answers that are needed.

This research will not stop the risk of your pigs getting sick. But we will give you advice about the best, simple ways that we know to keep your pigs healthy. We will wash our boots and hands with disinfectant so that we don't bring diseases from other places to your farm. After the research is completed, we will provide information to veterinary authorities and local leaders and ask them to tell you and other people in this village about what the research found.

During our research we may discover some disease that is very serious. We may need to tell the government veterinary authorities so they can take action to stop the disease spreading. We will tell the veterinary authorities the name of the village where we have found the disease. We will not tell any specific information about your pigs or your farm unless this is very important to stop lots of other pigs and people being affected by the disease.

Contacts for questions or problems about the research

If you have questions about the research after today, you should contact one of these people on the BecA-ILRI research team

Project coordinator and fieldwork leader

Dr Edward Okoth +254 725 082 458

Farmer study leaders

Dr Noelina Nantima +256 772 515 962

Dr Jacqueline Kasiiti +254 733 707 685

Project leader

Dr Richard Bishop +254 710 831 851

We need to know if this research is causing problems for you or other people. If you have a problem from the research, please tell us. You can also report the problem to the leaders in your village and ask them to talk to us. Or you can report the problem to your District Veterinary Officer (DVO) who will talk to us about your complaint:

Kenya DVOs

Busia District	Dr Oronje Ohato	+254 724 820 348
Butula District	Dr. Denis Odhiambo	+254 726 865 192
Nambale District	Dr Alan Ogendo	+254-723 312 854
Teso South	Dr. Polycarp	+254 788252210 /+254 208 004 645/ +254736 382 788/+254 708 905 032/ +254 720 173 446
Teso North	Dr. Odima.	+254-722625908

Uganda DVOs

Busia District	Dr Barasa Patrick	+256-772 346 867
Tororo District	Dr. Mukonge Tegule	+256-772 44 09 94

The project has been reviewed and approved by the CSIRO Social Science Human Research Ethics Committee, Australia. The Chair of the institutional ethics committee of International Livestock Research Institute, Dr Delia Grace, has also reviewed ethical issues in the project. Dr Grace can be contacted on *+254-20-422 3000*

Numbers to ring immediately if the pig we have bought dies

Kenya

Dr Edward Okoth	+254 725 082 458
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Appendix 11: Consent form for follow up study

Pig health and farmer livelihoods: Participant consent

I confirm that:

- I have understood the explanation of the research as set out in the project information sheet
- I have had the opportunity to ask questions about the research and I am happy that my questions have been answered
- I am happy to sell my young pig to the research team.
- I agree to be paid for my pig:
    - Full price of 6,000 Kenya shillings when the team comes back for their second visit to see the pig, in about 6 months time.

- One third of the full price now, one third when the team comes back in 3 months time, and one third when the team comes back in 6 months time.

- I will keep the pig in the same way as I keep/would keep my other pigs.
- If the pig dies I will contact the project team straight away so that they can examine the dead pig quickly. I understand that the project team will pay me the full price for the pig if I contact them straight away/within one day of the pig dying.
- I am happy to answer the questions that the research team asks me. I know that if I do not want to answer any question I can say "I do not want to answer that".
- I know that my answers to questions and samples from my pigs will be stored and used in ways that keep my name and the exact location of my farm private.
- I understand that the research team will tell veterinary authorities and local leaders about what the whole research project finds out, but might not tell me personally.
- The researchers can use photographs of my farm or family to tell other people good, positive stories and will give me a copy of any photographs they use. For these photographs:

I DO want the researchers to tell other people my name

I DO NOT want the researchers to tell other people my name

Date_____Village name_____Sub location/parish name_____

Participant name(1)_____Signature or mark

Participant name(2) _____Signature or mark

Telephone number (if available)_____

HH name, if different from participant name(s)_____

Pig number

Enumerator and translator statement: I confirm that:

I have fully explained the information that is included in this information sheet and consent form to the participant.

I have encouraged the participant to ask questions about the project and I have answered the participant's questions to the best of my ability.

I have not concealed any information about risks that may arise for participants and their pigs as a result of participation.

On behalf of the project I undertake to pay for the purchase of the pig, in accordance with the conditions agreed to by the participant.

Enumerator Name Signature Date_____

Translator Name Signature Date_____

Appendix 12: Follow up questionnaire

Barcode:

SECTION 1: GENERAL INFORMATION

1.1 Name of Enumerator_____1.1.2 Date (DD/MM/) ___/___/12. 1.1.3 Language of administration_____

1.1.4 District _____1.1.5 Division/County _____ 1.1.6 Location/sub county (LC3)_____

1.1.7 Sub-Location/parish (LC2)_____1.1.8 Village ((LC1)_____

SECTION 2: HOUSEHOLD INFORMATION

2.1 Details of household head and respondent

Respondent's Name	**Gender**

SECTION 3: PIG HUSBANDARY/FARM CHARACTERISTICS

3.1. Current pig structure

Breed category	**Grade /crosses**			**Local breeds**		
	Number	Unit price	Value (Shs)	Number	Unit price	Value (Shs)
Piglets (1-3 months)						
Weaners (>3 months)						
Sows (Pregnant or farrowed)						
Breeding boars						
Castrated boars						

3.2. Pig dynamics since the last visit

3.2,.1. Did you purchase any pigs since the last visit? If yes please provide the following information on the number of pigs purchased.

Category	No. of pigs	Unit price (Shs)	Total value (Shs)
Piglets			
Weaners			
Sows			
Breeding boars			
Castrated boars			
Total			

3.2.2. Can you give us more information to help find the person you bought this pig from, so that we can also interview them about pig-keeping?

First and last name	Relationship	Location (village name)	Contact (phone number)	Distance-1=<1km 2=1-5 km 3=5-10km 4=>10 km

3.2.3. Pig births and fate of the piglets

3.2.4. Pig sales

3.2.4.1 Number of pigs sold and their value since the last visit

Pig category	Number	Unit cost	Total value
Female piglet			
Male piglet			
Weaning female pig			
Weaning male pig			
Breeding sow			
Breeding boar			
Culled breeding sow			
Castrated Boar			

3.2.4.2. Can you give us more information to help find the person you sold these pigs to, so that we can also interview them about pig-keeping?

First and last name	Relationship	Location (village name)	Contact (phone number)	Distance-1=<1km 2=1-5 km 3=5-10km 4=>10 km

3.2.5. Number of pigs eaten and their value since the last visit

3.2.6. Pigs given out

3.2.6.1. Number of pigs given out and their value since the last visit

Pig category	Number	Unit cost	Total value
Female piglet			
Male piglet			
Weaning female pig			
Weaning male pig			
Breeding sow			
Breeding boar			
Culled breeding sow			
Castrated Boar			

3.2.6.2. Please give information for the **last three** households where you have given your pigs.

Pig category	Relationship	First and last name	Location (village name)	Contact (phone number)	Distance-1=<1km 2=1-5 km 3=5-10km 4=>10 km	Reason for giving away

Relationship options 1.=Neighbour 2.=Other farmer 3.=relative 4.=Friend 5=other

3.2.6.2.3. a) If gave out pigs to somebody to keep for you, how do you pay in cash since the last visit? _____

b) How much do you pay in kind? State the form _____.

3.2.7 Number of pigs stolen and their value since the last visit

Pig category	Number	Unit cost	Total value
Female piglet			
Male piglet			
Weaning female pig			
Weaning male pig			
Breeding sow			
Breeding boar			
Culled breeding sow			
Castrated Boar			

3.2.8. Number of pigs slaughtered and sold as pork and their value since the last visit

Pig category	Number	Unit cost	Total value
Female piglet			
Male piglet			
Weaning female pig			
Weaning male pig			
Breeding sow			
Breeding boar			
Culled breeding sow			
Castrated Boar			

3.2.9. Number of pigs dead and their value since the last visit

3.3. Manure output: .How have used manure from your pigs since the last visit?. State the value in Shs

1=No, not collected nor used	2= No, collected/piled up but not used	3= Yes, collected and used on field	4= Yes, composited before used on field	5=Yes, biogas generation	6=Yes-Sold	7=Yes , other use specify
Estimated value in Shillings						

SECTION 4: PIG FEEDING

4.1. What have you been feeding your pigs in the last three months?

1=Commercial pig feeds (including pellets**)**
2=Home mixed feeds
3=Purchased maize/flour **(Ugali**)
4=By products from food processing
5=By products from brew
6=House hold food leftovers
7=Swill
8=Crop residues from farm
9=Grass

4.2.For purchased feeds, how much have you spent since the last visit?_____

4.3. How much have you spent on food supplements (*omena, mukene,* vitamins, minerals) since the last visit?_____

4.4. Where do you get swill from?

1=Hotel/restaurant 2=Institutions (e.g. hospitals) 3=Neighbours, other villagers 4=Other (specify)

4.5. Does the swill or house hold food leftovers ever contain pork products or pig offal and slaughter waste?

1=definitely no pork products	2= do not know	3= sometimes contain pork products	4=always contain pork products

4.6. Do you treat the swill in any way before feeding your pigs?

1=boil feed that may have pork products	2= treat feed that may contain pork products	3= make Ugali	4= mix various feed sources	5=Not treated

4.7. Can you give more information about one location where you get your swill (Repeat for up to three sources)

1=Name	2= village name	3= phone number	4= distance (<1km, 1-5km)

SECTION 5: PIG HEALTH

5.1. Did you treat these pigs for external parasites since the last visit?

1=Yes 2=No

5.2. How did you treat them?

1=Mud baths/wallow	2=Vet	3=Self treatment	4=supervised dipping/spraying

5.3. How much did it cost? _____

5.4. Did you treat these pigs for internal parasites?

1= Yes 2=No

5.5. How much did it cost? _____

5.6. Have these pigs ever been sick since the last visit? 1=Yes 2=No

5.7. What were the symptoms?

1=Diarrhoea	2=lack of appetite	3=dullness	4=swaying gait	5=skin flash	6=respiratory problems	7=Sudden death
8=Vomiting	9=Coughing	10=Shivering	11=Foaming at mouth			

5.8. Did you go to anyone for help with the disease?

1=Yes (go to 7.15) 2=No

5.9. Who did you seek help from?

1=HH member	2=local leader	3=neighbour	4=relative	5=friend	6=other farmer	7=pig trader	8=livestock development officer includes (NAADS)
9=Livestock Development Officer includes DVO	10=NGO	11=Farmer organization/self help group	12=Youth group	13=School	14=church	15=Private provider	16=Agrovet shop

5.10. How much did it cost you to get help and treat the disease? (Shillings)_____

5.11. Who gave you help? (Please give contact details)

1=first and last name	2= village name	3= phone number	4= distance (<1km, 1-5km)

5.12 Did you report the disease to the veterinary authorities?

1=Yes 2=No

5.13. If you reported to vet authorities, how did you report?

1=mobile	2= physically	3= phone number	4= distance (<1km, 1-5km)

SECTION 7: EXPENDITURE OF INCOME EARNED FROM PIGS

7.1. What has your household used the income earned from pigs for since the last time

Expenditure	**Amount (Shs)**
Food for household	
Purchase of assets	
School fees	
Health	
Household events	
Farm inputs	
Other (specify)	
Total	

SECTION 8: ASF AWARENESS

8.1. Have you had pigs that got sick or died from ASF since the last time?

1=Yes 2=No

8.2. If Yes, Which month was the outbreak? (Month)_____

8.3. Who detected the disease?

1=Husband/HH 2= Wife 3=Daughter 3=Son 4=Labourer 5=other (specify)

8.4. Who attended to the sick pigs?

1=Husband/HH 2= Wife 3=Daughter 3=Son 4=Labourer 5=other (specify)

8.5. When there was an outbreak of ASF what did you do?

1=Reported to vet authorities	2=Reported to NGO	3=Reported to NAADS	4=Reported to private service provider
5= Self medicated	Slaughtered	7= Got advice from Agrovet	8 Never sought for help
9=Sold	10. Other (specify)		

8.6. Who reported the outbreak?

1=Husband/HH 2= Wife 3=Daughter 3=Son 4=other (specify)

8.7. How much did you pay? _____

8.8. Who paid for the visit?

1=Husband/HH 2= Wife 3=Daughter 3=Son 4=other (specify)

8.9. Please provide the following information on the number of pig sold during the ASF outbreak?

Category	No. of pigs	Unit price
Piglets		
Weaners		
Sows		
Boars		

8.10. How many of your pigs died from the recent ASF outbreak? _____

Category	Piglets	Weaners	Sows	Boars
No. of pigs				

8.11. How many of your pigs survived in the most recent outbreak? _____

SECTION 9: FOOD SECURITY

9.1. Do you eat pork in your household? 1= Yes 2=No

9.2. How often?

1=Never	2=Everyday	3=Often>once a week	4=regularly > Twice a month	5=Sometimes, once a month	6=Rarely, once/twice a year

9.3. Where do you usually get your pork from?

1=Home slaughter	2=Relative	3=Neighbour	4=Friend	5=Butcher	6=Restaurant/pork joint	7=other

Can you give us more information to help find the person you bought from so that we can also interview them about pig-keeping?

First and last name	Location (village name)	Contact (phone number)	Distance-1=<1km 2=1-5 km 3=5-10km 4=>10 km

10: BIOSECURITY

10.1. Have you used disinfectant on your farm since the last visit? 1=Yes 2=No
10.2. What type do you use? _____
10.3. How much did it cost? (Price litre/Kg)_____
10.4. When do you use disinfectants?

1=clean pig house	2=wash hands e.g. after animal handling	3=dead animal disposal	4=clean shoes of visitors to pig farm	5=other household use	6=other (specify)

10.5. How often?

1= Always	2=regularly	3=irregularly

10.6. Who makes decisions on whether to use disinfectants?

1=Husband 2= Wife 3=Daughter 3=Son 4=Collaborative. 5=other (specify)

SECTION 11: ADVICE AND TRUST

11.1. Where do you get information that is helpful for farming or for family and household issues? (Trust to give you this information)

1=radio	2=TV	3=news letters/books	4= Internet	5= household member	6=local leader
7=neighbour	8=relative	9=friend	10= other farmer	11=pig trader	12. livestock devpt officer (NAADS)
13. Livestock health officer (e.g. DVO)	14=Agricultural extension officer	15.=NGO	16= Farmer organization or self help group	17= youth group	18=Baraza
19. Public places					

11.2. If you have problem on your farm, who would you trust to give you advice or help?

1=HH member	2=local leader	3=relative	4=friend	5= other farmer	6=pig trader
7=. Livestock devpt officer (NAADS	8= Livestock health officer (e.g. DVO)	9= NGO	10= Farmer organization or self help group	11= youth group	12) school
13. Church	14= Agricultural extension officer	15=other			

Can you give us more information to help us find the person who you would trust for advice or help, so that we can interview them (allow options of adding more than one entry)

1=first and last name	2= village name	3= phone number	4= distance (<1km, 1-5km)

11.3. If you have a problem in pig-keeping, whom do you trust to give advice or help?

1=HH member	2=local leader	3=relative	4=friend	5= other farmer	6=pig trader
7=. Livestock dev't officer (NAADS	8= Livestock health officer (e.g. DVO)	9= NGO	10= Farmer organization or self help group	11= youth group	12) school
13. Private vet/service provider	14. Agrovet shop				

Can you give us more information to help us find the person who you would trust for advice or help so that we can also interview them (allow options for adding more than one entry)

1=first and last name	2= village name	3= phone number	4= distance (<1km, 1-5km)

Have you changed the way you keep your pigs since the last visit? NO YES

If yes, how?

Why did you decide to change?