MARKET PERFORMANCE AND RISK OF SPREAD OF FOOT AND MOUTH DISEASE THROUGH CATTLE MARKETING ACTIVITIES IN WESTERN KENYA

A thesis submitted in partial fulfillment of the requirement for Masters of Science in Veterinary Epidemiology and Economics

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DECLARATION

I declare that the work contained in this thesis was done by myself and has not been submitted to any University for any academic award.

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DEDICATION

I dedicate this thesis to my dear family; my wife Isabellah Kemunto and my daughter Jacinta Kerubo. Thank you for being my strongest supporters and best friends throughout the period of this study. To my father Simion Onduso, my late mother Alexina Kerubo and my brothers and sisters, thank you for your encouragement and love.

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LIST OF APPREVIATIONS AND ACRONYMS

AU = African Union

ASF= African swine fever

CSF= Classical Swine Fever

CPP = Caprine Pleural Pneumonia

ECTAD = Emergency Centre for Trans-boundary Animal Diseases

F**MD**= FootandMouth Disease

FAO= Food and Agricultural Organization

GDP = Gross Domestic Product

GOK= Government of Kenya

KNBS = Kenya National Bureau of Statistics

OIE= Office International des Epizootics

PPRV = Peste des Petite Ruminants Virus

RNA= Ribonucleic Acid

SVD = Swine Vascular Disease

SCVO = Sub-county Veterinary Officer

TBD= Trans-boundary Diseases

UK= United Kingdom

UN= United Nations

WHO= World Health Organization

ABSTRACT

There was a surge in the number of foot and mouth disease (FMD) outbreaks in western Kenya between the years 2014 and 2016. Cattle markets are believed to play a major role in the maintenance and spread of FMD virus within the region. A qualitative risk assessment was done to investigate the role played by cattle markets in maintenance of these outbreaks. The specific objectives of the study were to describe cattle marketing activities and practices that posed a risk for spread of FMD, conducting risk assessment for the spread of FMD through cattle marketing activities and analysis of structure and performance of selected cattle markets within the region. The risk assessment was done based on the framework adapted by World Organization for Animal Health (OIE) which entails hazard identification, release assessment, exposure assessment and risk estimation. A cross-sectional study was conducted in selected livestock markets in western Kenya to collect both qualitative and quantitative data using a semi-structured questionnaire. Additional data collection was done through focus group discussions with livestock traders in the markets while secondary data were also obtained through review of published and grey sources of literature.

The quantitative data collected were analyzed using descriptive statistical measures including frequency distributions and measures of central tendency: arithmetic mean and median. Gini coefficient were also calculated to estimate the cattle market concentration indices, while Lorenz curve were drawn to estimate the cattle traders market share in the selected livestock markets. Additionally, gross marketing margins were calculated to evaluate marketing performance in the region. For the case of risk assessment, the risk for release of FMD virus was determined by assessment of risk of FMD infected cattle moving through the livestock markets, ability of the virus to survive in environment, volume of cattle traded in the selected livestock markets and

cattle marketing practices which would increase exposure to infections. The risk of exposure to FMD infections was determined through assessment of the possibility of; infected cattle making susceptible contacts, marketed animals making infectious contacts, cattle from markets not being quarantined and FMD transmissions within and between the connected farms.

The Lorenz curves showed that about 80% of cattle traders in Kamukuywa market controlled only 58% of the market shares, with the remainder of 42% market share being controlled by only 20% of the livestock traders. These livestock markets had an estimated Gini coefficient of 0.65 indicating a higher degree of concentration. Bumala livestock market had fair distribution equality with a Gini coefficient of only 0.32, while Kimilili livestock market had the least distribution equality with an estimated Gini coefficient of 0.71.Therefore these cattle markets had an oligopolistic market structure characterized by only a few livestock traders controlling trading business in cattle.

The study shows that the risk of spreading FMD virus during an outbreak through cattle marketing practices was high. Inadequate facilitation of veterinary department, trade on non-vaccinated cattle, cattle evaluation practices, cattle movement without permits, trekking cattle for long distances, lack of isolation of traded cattle at farms and visiting of many livestock markets within short period, were some of the identified practices which could increase the risk of FMD spread through markets during outbreaks. There was free entry into this trade but challenges of obtaining the required operating capital and lack of adequate advance market information were the main restricting factors for traders.

This study recommends that some risk management measures' needs to be put in place to manage the high risk of FMD spread from markets. These may include adequate resource

Allocation to the veterinary department for disease surveillance activities, subsidizing cost of the strategic vaccinations and creation of awareness amongst traders on the roles they should play in cattle disease control and management. The government and other relevant institutions should also assist cattle traders to access affordable loans, ensure that there is adequate dissemination of market information and to develop standards for determining animal value.

CHAPTER ONE

INTRODUCTION

1.0 Background

Kenya has an estimated cattle population of 17.5 million, with an estimated annual off take of 2.9 million head of cattle. The contribution of cattle to Kenyan GDP is estimated to be Ksh. 356.217 billion, of which Ksh.53.960 billion is derived from domestic off take (Behnke and Muthami, 2011). In 2009, Kenya National Bureau of Statistics (KNBS) estimated that livestock provide about 45% of the total agricultural GDP in Kenya (GoK, 2012). Furthermore, it is estimated that the agricultural sector contributes about 26% of Kenya's GDP, and it employs about 75% of Kenyan population (Gok, 2005). Most of the beef production in Kenya is practiced by the pastoralist community who manages about 12.2 million head of cattle and produce about two thirds of the country's red meat (Behnke and Muthami, 2011 and Farmer *et al*., 2012).

Cattle are kept for many reasons which include social and cultural objectives however, recent studies have shown that commercial objectives is gaining more relevance in livestock keeping communities (Steyn *et al.*, 1992 and Fraser *et al*., 1992). Cattle farmers when faced with household financial need would sell their animals to meet these needs (African Union 2010). Agricultural markets performs many roles in any given economy which include linking of consumers to producers, thus they make it possible for exchange relationship to take place as well as increasing the standard of living (Adrika *et al*., 1977). Agricultural marketing brings out specialization in production, consequently improving skills and production efficiency (Olukosi *et al.,* 1990). Market environments can be assessed both at macro- and micro-levels taking into consideration both the intrinsic and extrinsic factors (Grant *et al*., 2008). These extrinsic factors are classified as political, economic, social,

technological, environmental and legal factors. Cattle diseases are also considered as extrinsic factors in cattle trade classified under environmental factors. Cattle purchased from agricultural markets are often destined for slaughter, breeding, fattening or production of raw materials for industries (Endris *et al*., 2011). Furthermore, cattle slaughterhouses are supplied by livestock traders through a chain of markets, which are often classified as primary, secondary and terminal markets. There are many players in these marketing chains who come from different ecologies and who can present substantial risk for the spread of diseases from one production system to another. For example, Jorge-Hernedez *et al*. (2007) identified purchase of animals from markets and from farms in close proximity to cattle markets or slaughtering facilities as risk factors for spread of cattle diseases in Ecuador. Therefore, livestock marketing activities play a role in the spread of FMD. Foot and mouth disease is a highly contagious, viral disease of domesticated and wild ruminants (Coetzer *et al*., 1994). The disease can be spread through a network of contacts, such that infection has a much higher risk of spreading to a more limited set of susceptible animal contacts. The FMD virus can be transmitted from infected animal to susceptible animal either through ingestion of contaminated material or through respiratory transmission. Aerosol transmission occurs mostly during physical or close animal to animal contact often following animal movement is the most common. This is closely followed by ingestion of contaminated materials; that can occur when there is consumption of contaminated water, concentrates or pastures (Donaldson *et al*., 2001, Sanson *et al*., 1994). Long distance spread can also occur through aerosol and fomites, or contaminated inanimate objects especially, motor vehicles, clothes and skin of animal handlers such as farmers and traders. The Terrestrial Animal Health code developed by OIE is used to regulate the international trade on animal and animal products.

The Code also gives guidelines used in risk analysis. Risk analysis is a process undertaken to evaluate the risk of an event occurring. It comprises various components including hazard identification, risk assessment, risk management and risk communication (OIE 2004). The risk of FMD spread through interactions of cattle in trade can be evaluated by carrying out risk analysis. New Zealand which is free from FMD often conducts risk analysis from time to time to determine its preparedness for FMD incursions (Pharo *et al*., 2002) while Australia was able to identify abattoirs and sale yards of small scale piggeries, and other production systems as the most likely routes of FMD incursions(Hernandez-Jover *et al*., 2016). In Somalia, animal inspection at the regional markets combined with quarantine measures have been described to reduce the risk of exporting infected animals and effectively enhancing disease control at regional level, thus avoiding exporting infected animals to international markets and risk being restricted to access international markets (Knight-Jones *et al*., 2013).

The motivation of this study was based on the fact that agriculture is the backbone of Kenyan economy and majority of rural population depends on it as the only source of income. Livestock marketing activities often involve movement of livestock from farms to various markets, and this creates networks connecting farms to these cattle markets. Livestock from various farms come into contact during movements and at market centers. These interactions at markets determine the level of contact and subsequent transmission of FMD.

In Western Kenya, cattle farming are practiced under small scale mixed holder system, in which farmers also produce sugarcane, maize, beans, cassava and millet (Paul *et al*., 2016). The Zebu and their crosses are the predominant breed kept by livestock farmers (Wanjara and Njehia 2014). Semi-intensive management is the preferred management system with animals communally grazed on open grazing fields; public land, schools, road reserves, swampy areas

along river banks and uncultivated private lands. With regard to cattle trading activities, Western Kenya has many cattle sale yards most of which are primary markets characterized by many speculators. In case of disease outbreaks under such management systems, the effect would be huge since many cattle would be exposed within a short time, and huge costs would be incurred by the government and farmers to effectively control such outbreaks, hence the need for enhanced disease surveillance systems within these connected markets. Understanding how these cattle marketing activities and cattle management practices in the region impact on the potential for transmission and spread of FMD among the farms is crucial for designing an efficient disease control program and surveillance system.

1.1 Research problem

Cattle farming and trading activities are major economic activity in Kenya (Farmer *et al*., 2012). Cattle markets play an integral role in livestock production activities since they create a platform for exchange of animal ownership from production to consumption (Andrika *et al*., 1977). Inherent within this platform are many risks for spread of animal diseases such as FMD.

Foot and mouth disease in cattle is mainly spread through airborne route which occurs when infected animal is in close contact with susceptible animal (Donaldson *et al*., 2001). This occurs mainly when animals from different production systems are moved long distances and brought together like is the case within livestock markets. In cases of FMD outbreaks, the impacts are often high since these affect all the players within livestock production, trade and consumption (Knight- Jones *et al*., 2013). Other effects of FMD outbreaks include livestock markets closure, trade bans by trading partner countries and regions making livestock farmers and traders unable to meet their financial obligations. The demand for beef would surpass supply making beef price to rise and nationally the GDP would be affected as huge amounts of money would be required

for the vaccination campaigns to control the outbreak. Kibore *et al*.(2013) in his study reported the prevalence of FMD in Kenya to be around 52% and about 100% in western Kenya. With such high FMD prevalence, and considering the farming systems and the roles livestock markets play in an economy of developing countries, it was important to identify gaps in the disease surveillance and practices which may increase risk for spread of diseases that exist in livestock markets.

The aim of this study was to analyze cattle markets and carry out risk assessment on marketing practices which contributes to spread of FMD in western Kenya. The findings from this study would provide important information to support development of cattle marketing infrastructures, provide information which could be used for policy development on disease surveillance and provide the basis for more research on cattle markets and disease transmission within the context of developing countries.

1.2 Research hypothesis

Cattle marketing activities in western Kenya have an effect on the transmission of FMD within connected farms and systems

1.3 Research objectives

1.3.1 Overall objective

The overall objective of this study was to investigate the risk for spread of FMD through cattle marketing activities and practices in western Kenya.

1.3.2 Specific objectives

1) To describe cattle marketing activities and practices that increases the risk of spread of FMD through cattle markets and farms in western Kenya

2) To conduct a qualitative risk assessment for the spread of FMD through cattle marketing activities

3) To analyze the structure and performance of selected cattle markets in western Kenya

1.4 Scope and limitation of study

This study was conducted in Busia and Bungoma counties in Western Kenya. It adopted the commodity approach in market analysis and used the OIE guidelines in risk assessment for spread of FMD. The study focused on live cattle markets therefore its findings may not be a true reflection of other livestock markets and cattle products in the region and other regions of the country. Only qualitative data was collected and used for risk assessment of FMD spread through cattle marketing activities.

The study focused on spread of FMD in cases of outbreaks, it did not consider the factors which cause the outbreaks and for the spread of FMD, it only considered spread through contact of susceptible cattle with an infected cattle or contaminated material. Contacts of cattle with wild animals were not considered in this study though it is a possibility considering the proximity of the region to Mt. Elgon National park.

This chapter has presented the background of the study, it has discussed risk analysis and how it has been used by different countries to evaluate their disease surveillance systems. Justification, scope and limitation of the study have been given and finally the chapter has presented the research problem, hypothesis and objectives.

The next chapter gives a review of FMD in details on etiology, epidemiology, risk factors, economic and social impact of the disease, routes of infection and mechanisms of spread, clinical signs, and control of the disease. Marketing concepts; cattle market channels, cattle market efficiency, and market structure, conduct and performance analysis are discussed and different

concepts in risk analysis are defined; interpretation of risk of occurrence given and approaches to risk assessment and components of exposure assessment, release assessment and consequence assessment are discussed. Finally the chapter presents literature review on empirical studies that have analyzed livestock markets.

CHAPTER TWO

LITERATURE REVIEW

2.1 Foot and Mouth disease

2.1.1 Disease etiology

Foot and Mouth disease is a highly contagious acute viral infection of cloven hoofed animals including domesticated ruminants, pigs and wild ruminants. It is one of the most important disease of economic importance to livestock keeping communities around the world (Coetzer*etal*.,1994).The disease is caused by a single-stranded RNA virus of the family *picornaviridae*, a member of the genus *Aphthovirus* (Belsham *et al*., 1993). Infection with FMD virus occurs when the single stranded RNA virus particle enters the host cell, configuring the host cell to manufacture many copies of the virus until it eventually bursts, releasing the new particles in the blood (Thomson *et al*., 2003). The virus is genetically highly variable which limits the effectiveness of vaccination (Mertinez-salas *et al*., 2011).

There are seven immunologically distinct serotypes; Southern African Territories, SAT 1, SAT 2, and SAT 3, serotypes, A (Allemagne), C (Island Riems), O (Oise) and Asia 1 (OIE, 2004). Within each serotype there are numerous strains (Van regenmortel *et al*., 2000). The incubation period for FMD virus is between 1 - 14 days depending on virus strain and dose, as well as site of infection (Artz *et al*., 2011). Infection with any one of the serotypes does not cause cross immunity against the other strains. The virus is highly infectious, and it is produced in high titer in respiratory secretions and in large volumes. In addition to this and the fact that the virus is stable in natural environment, its ability to replicate rapidly and the short incubation period

makes the virus spread rapidly in susceptible population complicating the control of the disease during outbreaks (Sellers *et al*., 1971).

2.1.2 Epidemiology of foot and mouth disease

The disease has a global distribution and is endemic in many parts of the world, particularly Africa, Asia and regions of South America (Knowles *et al*., 2003). The FMD status of any particular country or region can be defined as endemic, epidemic or free. The OIE recognizes 36 of the 162 member countries as FMD-free without vaccination (OIE, 2012). These are countries which have successfully controlled or eradicated the infection and have implemented strict control measures especially regarding imports of animals and animal products to prevent disease re-emergence.

The type O strain was first isolated in 1990 in Northern India. The strain then spread to over 28 countries and has caused outbreaks in former FMD free countries such as Japan, South Korea, eastern Russia, Mongolia and UK. In 2000, type A strain caused an outbreak in Argentina making it lose its recently acquired free status, Asia 1 strain caused outbreak in Greece. There have been outbreaks in Arabia and Kuwait caused by SAT 2 strains, and in South Africa caused by SAT 1 and O strains (OIE, 2012).

In Kenya and the rest of East Africa FMD is endemic with type A, O, C, SAT 1, SAT 2 and SAT 3 serotypes being the most common strains. SAT3 has been reported only in Uganda by Vosloo *et al.,* 2002. The FMDV serotypes in Kenya during the 2004 – 2006 outbreaks were types A, C, O, SAT 1 and SAT 2. Before this period most outbreaks were caused by serotype O and SAT 2 which remain to be endemic to date while during this period and more recently there has been an upsurge of SAT 1 and SAT 2 (Sangula *et al*., 2006). Outbreaks caused by serotype C are rare

with only one outbreak reported in 2004 while serotype A occurs on lesser frequency (OIE, 2009).

2.1.3 Risk factors for foot and mouth disease outbreaks

There are many factors associated with FMD outbreaks, these include; farm management, animal husbandry, animal trade (marketing channels and efficiency of livestock markets) and herd immunity (level of vaccination coverage and vaccine efficiencies), and human activity (Bronsvoort *et al*., 2005). Majority of the small holder farms do not have adequate knowledge on bio-security measures needed in their farms, which include the use of disinfectants at their farm gates, restriction of human traffic into the farms; including restriction of movement of farm workers, neighbors, animal health workers, farm equipment and sales people. A study in Thailand by Rojanasthien *et al*. (2006) reported that farms which do not use disinfectants are 2.28 times more likely to have FMD infections than farms which use disinfectants while farms which allowed AI officers to enter their farms were 5.12 times more likely to have FMD outbreaks compared to farms which does not to allow such external service providers.

The source of animal feeds, water and their management are also considered to be a risk factor for FMD spread. In extensive cattle management with communal grazing and watering, the frequency of animal contact from different household is high hence high risk of disease spread. In Thailand, villages which shared pasture were 1.6 times at risk of FMD than villages which were not sharing pasture (Rojanasthien *et al*., 2006), while villages which shared water source were 2.4 times at risk for FMD than villages which do share water source Cleland *et al.,* 1996. Similar study by Intha *et al*., 2009 reported that goats sharing grazing fields, animals crossing borders and cattle moving freely in the wild searching for pasture as risk factors for FMD outbreaks in Vientiane. This study was in agreement with a study carried out in Ethiopia by

Megersa *et al*., 2009 which reported that cattle raised with small ruminants were 5.1 times at more risk of FMD than cattle kept separate from small ruminants.

In livestock trade, animals are moved from different production system and long distances to the market where animals from various sources and to different destination interact. Sometime animals are moved through many markets before they get a buyer or before they are finally slaughtered. Production systems which bring in animals from other farms are 2.2 times at risk of FMD outbreaks compared to farms which do not bring in animals from other farms, (Bronsvoort *et al*., 2005). A similar study in Equador by Lindholm *et al*., 2007 reported that farms purchasing cattle from cattle market are 10.9 times more likely to have FMD outbreaks compared to herds which have not purchased cattle from markets. Allepuz *et al*., 2013 in their study in Tanzania had similar finding in which they reported that FMD occurrence has a higher correlation with animal movement and human activities and related this to proximity to public roads and railway lines.

Animal vaccination gives cattle protection against viral infections. Successful vaccination against FMD is dependent on vaccination coverage, vaccine efficiency and vaccination intervals. A study of FMD outbreaks in Israel by Elnekave *et al*. (2013) reported that farms with calves less than six months old or adult animals vaccinated more than six months earlier are at higher risk of FMD outbreak than farms without calves or vaccinated within six months.

2.1.4 Routes of infection and methods of spread

The FMD virus can be transmitted from infected animal to susceptible animal in a number of ways; Aerosol transmission is the most common route, which occurs mostly during physical or close animal to animal contact often following animal movement. This is closely followed by

ingestion of contaminated materials which occurs when there is consumption of contaminated meat, milk, water, concentrates or pastures (Donaldson *et al*., 2001). Long distance spread occurs through aerosol and fomites, especially contaminated motor vehicles, clothes and skin of animal handlers such as farmers and traders. Ruminants are primarily infected through the respiratory route while pigs are primarily infected through the oral route (Donaldson *et al*., 2001). The level of air contamination caused by infected animal varies with the virus strain, stage of infection and species of animal involved (Sanson *et al*., 1994), with pigs causing the most contamination and ruminants being most susceptible for infection by airborne virus. Various studies and computer models to assess the risk of airborne spread have been developed and established that it is only possible when short distances are involved, concentration of virus in the air and wind direction considered (Gloster *et al*., 1982). Cows can also get infection of FMD from the semen of infected bulls (Cottral *et al*., 1968).

2.1.5 Clinical signs of foot and mouth disease

The clinical signs of the disease include high fever of between 39.4-40.6°C (103-105o°F), that declines rapidly after two or three days, vesicle lesions on dental pad, gums, soft palate, nostrils, inter-digital space, coronary bands, muzzle, teat, and on the tongue (Woodbury *et al.*, 1995) which later raptures leading to copious discharge of contaminated saliva (foamy and drooling), nasal discharge, smacking of lips, grinding of teeth, kicking of feet and lameness (Stenfeldt *et al*., 2014). There is high concentration of virus on vesicle tissues. Adult animals often suffer weight loss because they are unable to feed due to ulcerations and pain in the mouth, muzzle and tongue from which they take several days to recover. There is lameness and mature males develop swelling in the testicles and in milking cows there is significant decline in milk production. Cattle are highly susceptible to FMD infections and display symptoms readily. They

are considered to be an indicator species for FMD outbreak. Most of FMD infected animals eventually recover. Some FMD cases develop myocarditis and eventually die, especially in newborn animals (Stenfeldt *et al*., 2014).

2.1.6 Economic and social impact of foot and mouth disease outbreak

Foot and mouth disease is characterized by high morbidity and low mortality (Coetzer *et al*., 1994). It has huge global economic impact due to large number of animals affected. These impacts include direct losses as a result of reduced production and change of herd structure as it causes abortions and infertilities, while indirect losses are due to control costs (vaccine production, procurement and vaccination logistics, limited access to markets and employment of improved technology) (Knight-Jones *et al*,. 2013). Countries which export animals and animal product are also affected following the banning of their products from lucrative markets which pays premium prices for livestock products. These countries loss earnings, industries close down and people working there lose jobs. For instance an FMD outbreak in Taiwan in 1997 resulted into the slaughter of more than 4 million pigs, with an approximated cost of $6 billion in its efforts to control the outbreak (Yang *et al.*, 1999). This outbreak made Taiwan lose its FMD free status and lost its pork export market. The FMD outbreak approximately made the country loose $15 billion (Huang *et al.*, 2001).

An FMD outbreak in Southern Korea in the year 2000 was controlled by slaughter and vaccination of cloven hoofed animals which resulted to slaughter of more than 500 000 animals mainly cattle, (Joo *et al*., 2002). A similar outbreak in Great Britain caused slaughter of all infected and in contact animals which caused a loss of approximately $29 billion (Defra *et al*., 2005). While in Kenya a single outbreak in a dairy farm with 200 cattle caused an estimated loss of Ksh. 1.2 million, (Mulei *et al*., 2001).

The effects of FMD outbreaks at individual farm level are devastating, as animal produce would go to waste while farmers cannot meet their financial needs as poverty levels rises. These may cause many social problems such as disruption of children's education, increase in domestic violence, depression and substance abuse. Community divisions and antagonism may arise as one group blames the other or service providers for being responsible for outbreak.

2.1.7 Control of foot and mouth disease

Globally, Food and Agricultural Organization of the United Nations (FAO) classifies FMD as a trans-boundary animal disease (TBAD) and has an Emergency Centre for Trans-boundary Animal Diseases (ECTAD). This plans and delivers veterinary assistance to member countries in case of a threat. The OIE classifies FMD as a notifiable disease and gives a set of safety guidelines and standards to assure safety of trade of animal and animal products. It also gives the guidelines on how to manage notifiable disease incursions.

Cattle vaccination, zoo-sanitary measures and destruction of infected animals have been used to control FMD outbreaks (Park *et al*., 2013). For countries free of the disease they employ stamping out strategy to control the disease in case of new incursions (OIE, 2014). Other strategies include quarantine, movement controls, zoning, tracing and surveillance, treatment of infected animal and animal products / by-products, disposal, decontamination, wild animal controls and vaccinations. Foot and mouth disease outbreaks in Netherland were controlled by ring vaccination in areas with high cattle population while ring culling was used in areas with sparse cattle population (Tomassen *et al*., 2002)

Ring vaccination around the outbreaks and movement restriction of animals and animal products has been used in Africa, Asia and South America to control the sporadic FMD outbreaks

(Asseged *et al*., 2005). In Kenya animal disease control is coordinated by the office of the Director of Veterinary Services (DVS) through the Sub-county veterinary officers who works closely with farmers and other stake holders. The control measures used include ring vaccination of all animals in 10 kilometers radius around the outbreak and restriction of animal and animal product movement from the outbreak region (Ngulo *et al*., 1980; Ngichabe *et al*., 1984). However, these control measures have not been applied at an intensity that could curtail the transmission and maintenance of the disease (Kibore *et al*., 2013).

2.2 Assessment of livestock markets

Market is defined as an area in which exchange of goods and services take place (Abbott and Makeham, 1979). It refers to people living in a given area with resources to produce and consume goods and services. The limits of a market are set by easy of transportation, communication, monetary and political barriers to free movement of goods and services. Marketing is a system which comprise of several interrelated activities along production, distribution and consumption (Mendosa *et al*., 1995).

Mendosa *et al.* (1995) outlined different approaches which can be used in livestock market assessment. These include functional approach, institutional approach and commodity approach. Functional approach is the study of activities which transforms livestock to forms desired by consumers. These include physical functions, facilitating functions and exchange functions performed by markets. Institutional approach emphasizes on who is doing what in the market. It identifies the businesses and other entities / actors that add utility to the various marketed products. These actors include middlemen, processors, manufactures and facilitators. Commodity approach follows a product from a point of production to the final user of the finished product such as poultry, pig, cattle etc, from the farm where they are reared to the table

when meat (beef or pork) is consumed. In this approach, both functional and institutional approaches are combined into one. It allows in-depth analysis but ignores between product and market interactions, (Kohls and Uhl, 1985).

The physical functions of a market help to maintain the smooth flow of products from producer to consumer and their alterations to the attractive forms. The elements of physical functions are transportation, market place facilities and services which include fences, holding ground, loading ramps, veterinary inspection posts ,grading, standardization, processing and storage facilities for carcasses (Tsefaye *et al*., 2008; Kohs and Uhl, 1985).

Facilitating functions include provision of reliable market information and credit services (Tesfaye *et al*., 2008). Adequate market information can be relied on to predict cattle prices and quantities of traded cattle and other services, forecast of future supplies and demand and overall market conditions. The market information must be timely, accurate and all inclusive (Asfaw *et al*., 2011). This would enable all market participants to make transactions with a well-informed judgment. In addition, easy access to credit services allows large numbers of traders to enter into a market and increase the financial capacity of small scale traders to expand their business which creates competitiveness (Ayele *et al*., 2003).

The exchange function involves finding a willing buyer and seller, negotiating prices and transferring ownership (Barau *et al.*, 1993). The most important element of this function is price determination mechanism. The price of an animal is often determined by on spot negotiation (Aklilu *et al*., 2002) taking into consideration of animal attributes such as weight, age, sex, and body condition, market characteristic such as behavior of market participants (buyer and seller) and time of transaction (Tsedeke *et al*., 2007).

2.2.1 Cattle marketing channels

Market channels refer to alternative routes cattle moves through from the farms to the consumers of finished animal products (Kohls and Uhl, 1990). This approach focuses on the industry's selling strategies to meet the consumer needs. Most cattle farmers do not sell directly to final consumers. There are many intermediaries (cattle traders) performing many functions between farmers and consumers. In livestock trade, cattle markets are classified into three stages: primary, secondary and terminal markets (Ayele *et al*., 2003). Primary traders are small-scale traders who purchase animals directly from farms and supply local butchers or trek them to distant markets where they sell them to medium-scale Secondary traders. In turn secondary traders are medium scale traders who supply terminal markets or major slaughterhouses in larger urban areas, (Belete *et al.,* 2009). Hundreds of kilometers are normally covered before terminal markets are reached since most slaughter animals are transported (or trekked) from arid and semi-arid areas to urban consumption centers (Farmer *et al*., 2012).

There are five major cattle trading channels available to small holder famers, (Musemwa *et al*., 2010). These include abattoirs, butcheries, auctions, private buyers and speculators. The marketing channels of pigs in Nigeria was reported to be from producers to rural assemblers to urban wholesalers to retailers and finally to rural and urban consumers (Ajala *et al*., 2008) while poultry market channels in Ethiopia were reported to be from producer to village collector to urban assembler to wholesaler to retailer and finally to consumer (Awol *et al*., 2010). Speculators play a significant role in the spread of cattle diseases as they link the five channels. They move animals from one cattle market to another within a short time without regard to their immunity or health status with an objective of making margins, (Kirsten *et al.,* 1993).

There are many factors which influences the marketing channel adopted by cattle farmers. Thomas *et al*. (2014) in their study in Namibia reported that gender and education level of household head, availability of market information and numbers of cattle sold were the factors determining the cattle marketing channels used by farmers. Maxwel *et al*. (2015) reported that negotiation, availability of market information and need to monitor marketing cost have greater influence on marketing channel in South Africa. Efforts to control notifiable cattle diseases (FMD, Caprine pleural pneumonia, anthrax etc) have also been found to be of greater influence in cattle marketing channel adapted; Jori *et al*. (2008) emphasized the need for quarantining animals as they are moved from disease prone area to disease free areas. Quarantining of cattle is associated with high costs and loss of condition thus animals fetching less in the terminal market. If such quarantines and movement restrictions are not observed cattle marketing channels can be a risk factor for spread of diseases as animals are often moved from different production systems, sometimes across the border to reach the sales yards, destination farms or abattoirs (Allepus *et al*., 2013)

2.2.2 Cattle marketing efficiency

Marketing efficiency is the movement of goods and service from producers to consumers at the lowest cost consistent with the provision of the standards that consumers desire and are able to pay for. Mehta *et al*. (2002) defines an efficient market as a market which is able to move goods and services from the place of production through distribution to the point of consumption in a manner that is beneficial to the producer, market intermediaries and consumers. In agricultural markets there are two aspects of marketing efficiency, technical / operational efficiency and pricing / allocative efficiency. Technical efficiency is concerned with operational activities involved in movement of animals from the farms to markets and to final destinations, which are

either new farms or slaughtering facility. If bio-security and movement restrictions are not properly adhered to, movement of animals through various marketing channels can be a great risk to disease control. Price efficiency is concerned with the price making role, how accurate, effective, rapid and freely market price is determined (Andargachew *et al.*, 1990). Whichever method used in livestock marketing should put into consideration the risk of spreading of notifiable disease.

The degree of efficiency attained in a market affects the general public as it affects the producer's price, the trader profit level and costs to the consumer (Sarhan *et al.*, 1988). An efficient market means better performance of the market and it is the common goal of farmers, traders and consumers. Such markets minimises marketing charges and farm production costs (Kohls and Uhl 1985). Based on this argument, in an inefficient cattle market, farmers change their production systems and animal husbandry practices and are unwilling to spend in their farms. They will not be willing to observe bio-security measures such as animal vaccination thus increasing risks of disease spread. While traders will attempt to reduce marketing costs, by preferring cheap means of transport and make attempt to get animals cheaply from farmers by changing their conduct in the markets. All these activities will increase the risks of disease spread.

Market efficiency is affected by weather, government policy, market forces and price instability arising from input costs and availability (Mehta *et al*., 2002). A study in goat and goat meat markets in Malawi by Maganga *et al*. (2015) reported that marketing efficiency was positively influenced by market experience, producer household size, education level, food security status, livestock extension services and availability of market information while it was negatively affected by distance to road network. Ajala *et al*. (2008) in their analysis of pig markets in

Kaduma State in Nigeria reported that the pig markets were profitable but inefficient. Factors contributing to market efficiency are evaluated by conducting market structure, conduct and performance analysis.

2.2.3 Structure, conduct and performance analysis

Market structure, conduct and performance analysis was developed by Kang *et al.* (2009). It states that the market structure (environment) determines the market conduct (behavior of market players) and set the level of market performance. Market structure influences the competitive conduct of firms in the market and firms in the market influences market performance. The performance of agricultural market is assessed based on the level of competition and efficiency.

Market structure is defined as the degree of buyer and seller concentration, entry conditions, and extent of product differentiation (Scott *et al*., 1999). This refers to the degree of competition and pricing in the market. Market structure classifies markets into perfectly competitive, monopolistic or oligopolistic depending on the level of market concentration.

Market concentration refers to number of sellers/ buyers in given market and the volume of business they control. The higher the concentration levels in a market the higher the degree of monopoly and absence of competition. Competitive markets have low market concentration and low market powers. Market power is defined as the concentration of resources in the hands of single or few market participants. It influences the conduct of market players.

Market conduct is the behavior pattern of market participants in adopting to markets they operate in. This includes assessment of human behavior patterns on price setting behavior, buying and selling practices and profit maximization (Kizito *et al*., 2008). This can be manipulated to be exploitative such as unfair price setting practice (cartels, collusion and mergers) and biased access to market information. In cattle trade, speculators will employ all sorts of tricks to

convince farmers to let their animals go as cheaply as possible, Kisrten *et al*.(1993). In some circumstances they move from farm to farm, from market to market and at times during disease outbreak they even circumvent the quarantine restriction to make high margins without regard to the risk of spreading cattle disease.

Market performance refers to how well the market fulfils certain social and private objectives, which include acceptable price levels, price stability, profit levels, costs, efficiency and quality and quantity of food commodities (Kizito *et al*., 2008). Market performance is determined by market conduct and two major indicators of market performance are net returns and marketing margins.

2.2.4 Empirical studies on analysis of livestock markets

Many studies have been carried out to analyze the performance of different agricultural markets. Ajala *et al*.(2008) in their study in Nigeria, they analyzed the efficiency and profitability of pig markets, by evaluating the structure, conduct and performance of the markets using Gin coefficient and market margins. The pig market was found to be oligopolistic with easy entry but high operational costs. A similar study was done by Girei *et al*. (2013), on assessment of cost and returns of cattle markets in Nigeria. In their study, market structure and performance were analyzed using Gini coefficient and market margin analysis. The study reported the cattle market as being oligopolistic, profitable and highlighted on some constraints which make the operational costs to be high.

Similar findings have been reported by many studies including a study by Zewdiekifle *et al*. (2014) in Ethiopia. In their study they assessed the performance of goat marketing system in Ethiopia and reported that the goat market is oligopolistic characterized by poor market place services, inadequate market information, poor access to markets and lack of credit services.

Another study by Awol *et al*. (2010) on analysis of poultry market chain in Ethiopia focused on marketing of live birds and eggs. In this study, market players were categorized as village collectors, urban assemblers and wholesalers. Poultry marketing chain was found to be profitable, oligopolistic and faced with challenges of lack of support market services such as storage facilities, poor market information, lack of capital and poultry diseases.

In Kenya, Onono *et al.* (2015) in their study of constraints and efficiency of cattle markets, reported that the cattle markets were characterized by few traders controlling large market shares and that these traders were making good margins. The study also ranked the constraints faced by cattle traders and listed cattle marketing factors which may increase the risk of infectious disease spread as markets integration, disease occurrence and trekking of cattle to markets.

2.3 Risk analysis

Risk analysis is a process undertaken to deal with matters which pose a potential danger and are managed according to certain standard procedure. It is used to evaluate the systems put in place to determine their weaknesses in order to take precautionary measures such as the case of New Zealand and Australia in maintaining once their FMD free status (Pharo *et al*., 2002, Hermandez-Jover *et al*., 2016) or in determining the risk of a particular hazard occurring in a given situation. The process involves hazard identification, risk assessment, risk management and risk communication. Hazard can be a biological, chemical or physical agent with the potential to cause adverse health effects (OIE, 2014). Risk is defined as the likelihood of occurrence and the magnitude of consequences of a specified hazard being realized while risk management is the process of weighing policy alternatives in consultation with all interested parties considering risk assessment and other factors to implement the best policy alternative to eliminate or reduce the risk (OIE, 2004). Risk communication is the exchange of information between risk assessors,

risk managers and those affected by both the risk and the decisions taken before the final policy decision are adopted (Solenne, 2008).

Risk analysis studies can be qualitative or quantitative. Qualitative risk assessment are done where there is no enough data to carry out quantitative assessment and the risk of occurrence of each event is assessed for classification and described as being negligible, low, moderate or high(Zepeda *et al*., 1998). The event is described as negligible when the risk of occurrence of the event is sufficiently low to be ignored or if the event is possible only in exceptional circumstances, as low when the occurrence of an event is a possibility in some cases, as moderate when the occurrence of the event is a possibility and as high when the occurrence of the event is clearly a possibility.

A semi-quantitative risk analysis study done by Salonne *et al*., 2013 to assess the risk of introducing African swine fever (ASF) to European Union through illegal importation of pork and pork products reported that the risk of release was high from France, United Kingdom German and Italy but moderate from Spain. On exposure the study reported a high likelihood to France, Poland, Italy, Spain and Romania while it was moderate in Australia, Bulgeria, Greece, Germany, Hungary, Sweden, Portugal, and United Kingdom. Returning livestock trucks and legal meat imports were reported as the most risk routes of classical swine fever virus (CSFV) spread from German and Netherland into Danish swine population (Bronsvoort *et al*., 2008). This risk can drastically be reduced if mitigating measures are put in place. Another study in Great Britain using a quantitative risk model estimated the illegal importation of meat to be 11 875 tonnes of which 64.5 – 565 kg was contaminated with FMDV (Wooldridge *et al*., 2006).

2.3.1 Approaches to risk assessment

There are two approaches to risk assessment. The OIE Risk Assessment Framework and the codex Alimentarus Commission Code approach. The Alimentarus Commission Code contains a set of food standards which were adopted by a joint FAO / WHO codex alimentarius commission. The main objective of the Code and the Commission is protecting consumer's health and ensuring fair practices in the food trade. It has standards for all principle foods whether processed, semi-processed, raw and to an extent materials for further processing into food. It gives the requirements on food hygiene, food additives, residues of pesticides and veterinary drugs, contaminants, labeling and presentation, methods of analysis and sampling, import and export inspection and certification.

The OIE Risk Assessment Framework is an objective method of assessing the disease risk associated with movement of animals, animal products, genetic material, feed stuffs, biological products and pathological materials. It suggests that any risk assessment has to start with hazard identification followed by the risk assessment of an identified hazard occurring. The risk assessment of an identified hazard occurring is a function of the risk of the hazard occurring and the magnitude of consequences of such an occurrence. The risk of an identified hazard occurring, in turn, is the product of release of the hazard to the environment and the risk of exposure to the hazard. The magnitude of the consequence should take into consideration the risk of dissemination of the hazard and the impact it creates. The guideline proposes that for a qualitative assessment each of the events be characterized by a number of parameters and that each parameter is analyzed on the basis of all available information. Risk of release and exposure to hazard takes the following parameters into consideration; biological factors, Country factors

and commodity factors. While consequence assessment takes into consideration direct and indirect consequences (OIE, 2004)

.

2.3.2 Biological factors considered in risk assessment

The biological factors considered in release assessment are; the species, age and breed of animals involved, the pathogen predilection site, vaccinations, testing, treatment and quarantine at the source of animals. While for exposure assessment the biological factors considered are properties of the pathogen.

2.3.3 Country factors considered in risk assessment

For release assessment Country factors considered include; the disease incidence/prevalence, evaluation of veterinary services, surveillance and disease control programs and disease zoning systems of the region where animals are moving from. While in exposure assessment, the Country factors considered are; presence of potential vectors, human and animal demographics, customs and cultural practices, geographic and environmental characteristics of region (Country) animals are moving to.

2.3.4 Commodity factors considered in risk assessment

Commodity factors considered in release assessment are, quantity of commodity to be imported, ease of contamination, effects of processing the commodity, effects of storage and transport of the commodity. On the other hand in exposure assessment the commodity factors considered are; quantity of the commodity involved, intended use of involved animal or animal products and the disposal practices at the destination region.

2.3.5 Consequences in risk assessment

The consequences of a hazard occurring can be classified as either long term or short term. The short term consequences include animal infections, production losses and public health consequences. Long term consequences include surveillance and control costs, compensation costs, trade losses and adverse environment consequences

2.3.6 Empirical studies on risk assessment and cattle diseases

Several studies have been carried out on risk assessment for disease spread from one production system to another. In Russia, Moutou *et al.* (2001), in their study they qualitatively assessed the risk of introducing FMD into Russia and Europe from their neighboring countries. They reported that overall risk of introducing FMD to Russia was low with negligible magnitude of economic consequences and risk of hazard occurrence was considered to be moderate. While a quantitative risk assessment study conducted in Great Britain to examine the disease risk to its livestock population to FMD, classical swine fever (CSF), African swine fever (ASF) and Swine Vascular disease (SVD) from smuggled meat products from any region of the world. The study described the development of quantitative risk assessment models and discussed the challenges faced when undertaking such complex risk assessment models (Wooldridge *et al*., 2006)

In another study Pharo *et al*., 2002 carried out a review of FMD risk assessment facing New Zealand. The study reviewed the pathogenesis, virus survival, routes of infection, and methods of spread and presented the summary of major risks of introduction, disseminations and risk management measures in place. The study concluded that the only remote possibility of FMD incursions in New Zealand was through feeding of pigs in small backyard farms (unregistered farms) with illegal imported (smuggled) infected animal products. This was in agreement with a study done by Hermandez-Jover *et al.*, 2016, which suggested that there was extremely low risk

of FMD virus exposure to the pig industry in Australia, with exposure through direct swill feeding being 10 – 100 times more likely to occur than contact with infected pig. The virus is more likely to spread from small scale piggeries selling at sales yard and abattoirs than any other production system.

Qualitative risk assessment studies have also been done in Africa by Chazya *et al.* (2014), who determined the risk of incursion of Peste des Petits Ruminants virus (PPRV) in northern Zambia from Tanzania through trade of live goats. These authors reported high risk of occurrence with high economic consequences. In their study, the following parameters were used to assess the overall risk of PPRV spread to Zambia from Tanzania; risk of infected goat being selected for export, volume of trade, risk of missing an infected animal during screening, viability of PPR virus in transit and the potential of the virus for infection. In South Africa, Jori *et al*. (2008) carried out a qualitative risk assessments study on factors contributing to FMD outbreak in cattle along the western boundary of Kruger National Park. The study identified the most risk factors for the outbreak as; fence permeability, vaccination coverage and efficiency of animal movement control measures.

In Ethiopia a qualitative risk assessment of introduction of H5N1 virus through trade was done by Olive *et al*. (2007). Though the study identified risk areas as, live bird markets, backyard production, multiplication centers and commercial farms, it rated the risk of H5N1 introduction into Ethiopia as negligible. Another study on risk assessment and cost–effective animal health certification methods for livestock export was done in Somalia by Knight-Jones *et al*. (2013). The study reported that animal inspection and certification at regional markets combined with quarantine as ways to effectively reduce the risk of exporting infected animals and enhance disease control.

The chapter has reviewed FMD and various concepts considered in market assessment. These include details on etiology, economic and social impact of the disease, clinical signs, routes of infection and mechanisms of spread, epidemiology and control of the disease, approaches to risk assessment and concepts in risk analysis have been defined. Market concepts; market efficiency, market channels and structure, conduct and performance analysis have been discussed and finally the chapter present literature reviews on various studies on risk assessment and cattle diseases and analysis of agricultural markets. The cattle resources are considered as goods produced by farmers and have to go through various distribution channels to get to the consumer of final cattle products. Market structure, conduct and performance assessment is used to determine the degree of market competition, behavior of market participants to manage competition and the level of returns and market margins. Further, the market conduct provides useful information in risk assessment of disease spread.

The next chapter will present details of research design, description of the study area, study units, data collection and analysis approaches which were adopted for this study.

CHAPTER THREE

MATERIAL AND METHODS

3.1 Description of study area

The study was conducted in Western Kenya and involved two Counties. These two Counties were purposively selected for the study and they are Busia and Bungoma (Figure 1). Busia County comprises of seven sub-counties; Teso North, Teso South, Busia, Nambale, Butula, Bunyala and Samia. The county is found between latitude 0° and 0°45" North and longitude 33°54° and 34°25° East. Busia county has a surface area of 1,695 square kilometers (Km^2) and a population of 816, 452 people. The altitude is between 1,130m and 1,500m above sea level. The mean annual rainfall is between 760mm and 2,000mm, the mean annual maximum temperature ranges between 26°C and 30°C while the mean minimum temperature range between 14 and 22°C. The livestock markets selected for this study in Busia County were located in Butula, Bunyala and Teso North Sub-counties. Livestock farmers in Busia County practice mixed farming which included cattle keeping and cultivation of maize, sugarcane and cassava crops. Busia County was selected for this study because it is at the Kenya Uganda border with two legal border crossing points at Busia and Malaba towns and the communities staying in this county have their relatives in Uganda.

Bungoma County has a population of 1,375,063 people and an area of 2,069 km². Temperatures range from minimum of between 15 – 20 °C to a maximum of between 22 – 30 °C. It has two rainy seasons with average rainfall from 1,200 to 1,800mm per annum. Its economy mainly depends on agriculture, centering on sugarcane, maize and livestock industries. Bungoma County has nine sub-counties; Bumala, Bungoma Central, Bungoma North, Bungoma South, Bungoma West, Kimilili, Mt. Elgon, Webuye East and Webuye West. The selected study markets were

located in Kimilili, Bungoma North and Bungoma South Sub-Counties. Bungoma County was selected for this study because of its close proximity to Mt. Elgon National Park, it is at the Kenya Uganda border and at the transit line of beef cattle from producing counties of Turkana, West Porkot and Keiyo Marakwet to urban and peri- urban beef markets of Kakamega, Kisumu, Bungoma and Busia towns.

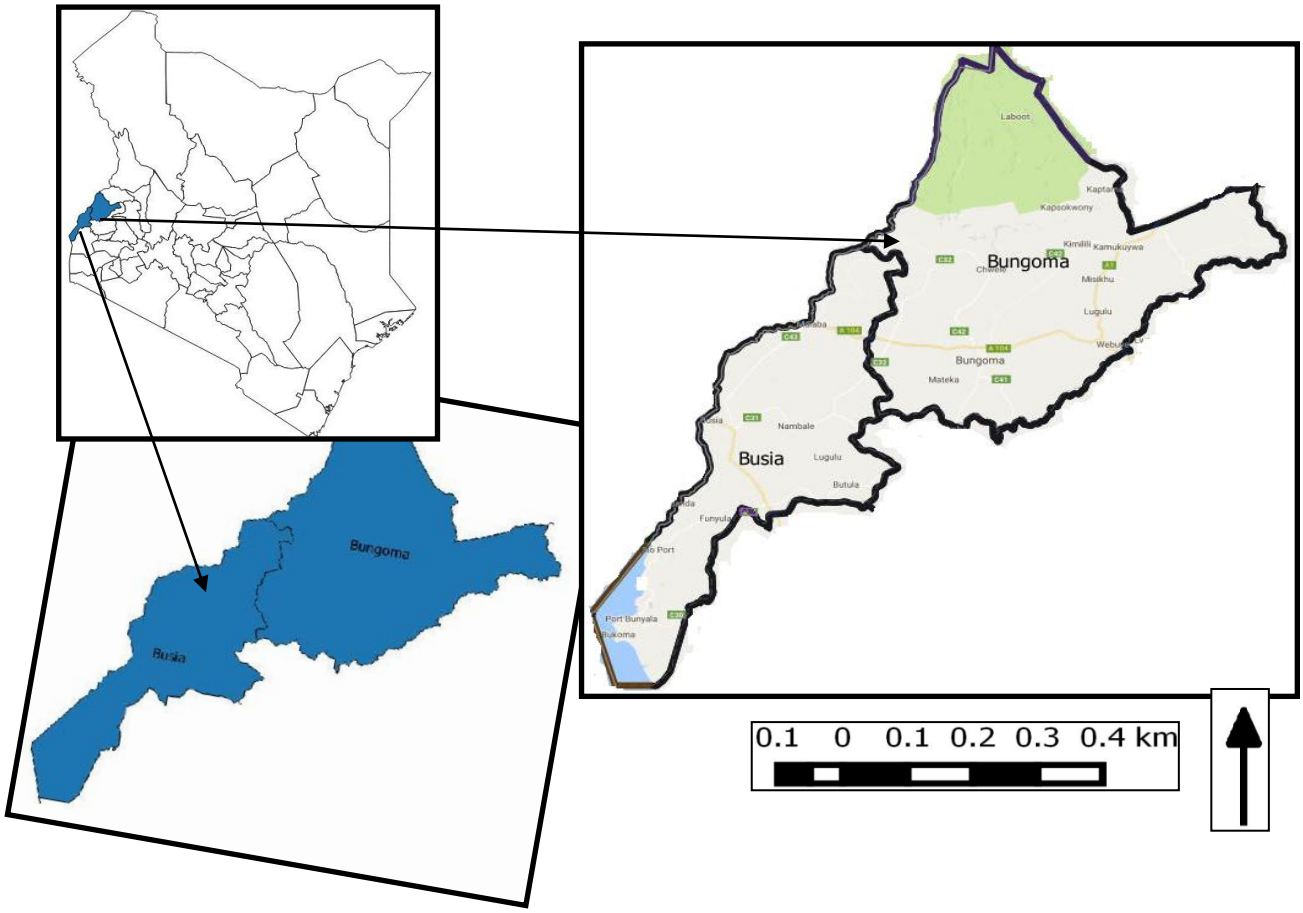

Figure 1. Map of Kenya showing Busia and Bungoma counties

3.2 Selection of study units

The markets included in the study were Bumala, Funyula and Amukura in Busia County and Kamukuywa, Chwele and Kimililiin Bungoma County. These markets were purposively selected because of different reasons; Funyula and Amukura were considered as major markets along Kenya-Uganda border while Kamukuywa, Bumala, Kimilili and Chwele markets were considered as major markets located on cattle transit routes from Northern Kenya; Kenya-Ethiopia border and Kenya-Uganda border through Turkana, West Pokot and Elgeyo Marakwet Counties to major urban centers in Western Kenya(Kakamega, Bungoma, Busia and Kisumu). All livestock traders who traded in these markets were identified and asked to respond to the questionnaire. The traders who were interviewed were those who had brought animals for sale in the local markets or those who purchased cattle from the local markets and were to resell them in another market or for slaughter.

3.3 Data collection

This was a cross-sectional survey study which employed both primary and secondary data collected within single period of time from the study area. This design was chosen because it was considered less expensive and required less time to collect both quantitative and qualitative data using participatory epidemiological tools. The data collected from this study allowed easy computation of the statistics from which interpretations were easily made. The primary data on cattle markets and marketing practices were collected on seven key areas using a structured questionnaire. The seven key areas were animal movement, disease control activities, livestock trading activities, cattle pricing practices, marketing costs, sources of working capital and characteristic of respondents. Data obtained from these key areas were on the sources and destination of traded animals, average cattle numbers purchased by traders and the average market price per animal, whether there had been FMD outbreaks in the region and how many

outbreaks had occurred in the last two years, If traders had been able to buy or sell cattle during quarantine periods, how movement permits were issued and their uptake by livestock traders, mode of transport of traded animals and average time taken from one market to another, if there was quarantine of traded animals at traders own farms, how cattle prices were determined, who had more influence to determining the market prices and availability of prior market information. Also a total of six focus group discussions were held with groups of traders in cattle markets. Other participants were officers from county Animal Production Department and an officer from County Veterinary Services Department. Discussions with these groups were guided using a checklist questionnaire. Additionally a semi- structured questionnaire was administered to the participants to collect data from individual cattle traders.

Additional data was collected from the markets by having transect walks to the selected cattle markets during marketing days during which data was collected through observations. Secondary data were also obtained by reviewing of disease outbreak records from the Veterinary Offices located in the study area, previous published studies and literature on livestock markets and occurrence of FMD.

3.4 Data analysis

The quantitative data collected were entered in Excel spreadsheet (Microsoft Corp), coded and then imported to Statistical Package for Social Sciences (SPSS 20 Version) for analysis. Descriptive statistical analysis was done and measures of central tendency and dispersion were derived (frequency and mean). The results were presented using tables and graphs. These results were then used to examine and describe different dimensions of cattle markets in Western Kenya such as market structure, conduct and performance. In addition, market structures were analyzed

through estimation of Gini coefficients while market performance was estimated through derivation of trader's market share and percentage gross marketing margins.

Trader's market share was calculated using the formula described by Pomeroy and Trinidad (1995). This formula is based on the number of cattle purchased by each trader expressed as a percentage of the total number of cattle purchased in that market on a particular trading day.

$$MSi = \frac{\text{Vi}}{\sum Vi}$$

Where; *MSi* = the market share of the *i*th traders

V*i* = the number of cattle purchased by the *i*th traders

$\sum Vi$ = the total number of cattle purchased from each market

Analysis of market structure was done using Gini coefficient. Gini coefficient determines the extent of sellers' concentration. The Gini coefficient was calculated using the formula described by Ajala and Adesehinwa (2008).

Gini coefficient = $1-\sum XY$

Where; X= Proportion of cattle marketers

Y = Cumulative proportion of number of cattle purchased

$\sum$ = Summation sign

The value of Gini coefficient ranges from 0 to 1. A Gini Coefficient of 0 implies perfect equality in distribution, while a coefficient of 1 means perfect inequality. The closer the value is to unity, the greater the degree of inequality and therefore, the higher is the level of concentration. In

other words, higher Gini coefficient means higher level of concentration and consequently high inefficiency in the market structure.

Analysis of cattle market performance was done by assessment of gross marketing margins. The marketing margin is a measure of the percentage of the price paid by the consumer that is maintained by each actor along the marketing chain. For this study percentage marketing margins were calculated using the following formula adapted by Muhammed *et al*. (2013).

$MM = Ps/Sp * 100$

Where; MM = Marketing margin

Ps = Price spread

Sp= Sale price

Price spread = Sale price – Purchase price

3.4.1 Pathways for spread of foot and mouth disease from cattle markets

The possibility of occurrence of the risk (spread of FMD virus from cattle markets in case of an outbreak) was equated to the risk of an infected cow being selected for sale at the farm level and transported to the market (release assessment) combined with the risk of exposure of susceptible animals to FMD virus excreted by infected animal (expose assessment, Figure 2).

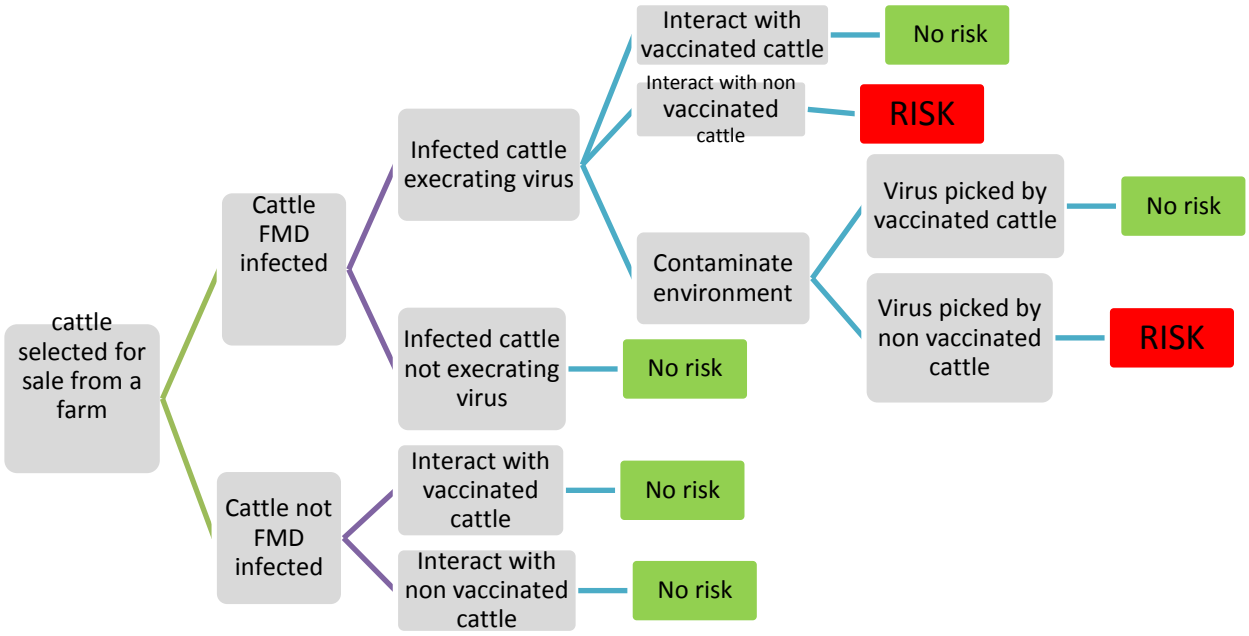

Figure 2. Foot and mouth disease risk assessment framework

The qualitative data collected on cattle marketing practices was to describe the market conduct. Furthermore, these data was used to perform a qualitative risk assessment for the spread of FMD following an outbreak through connected cattle markets and farms. The qualitative risk assessment was done following the OIE risk assessment framework which has been adopted by different authors in previous studies (Jori *et al*,. 2009, Moutou *et al*,. 2001, Wooldridge *et al*,. 2006). The OIE risk assessment framework entails: hazard identification, release assessment, exposure assessment, consequence assessment and risk estimation.

Hazard identification was done by assessment of both primary and secondary data obtained in the study area on disease aspects which include; previous FMD outbreaks, prevalence of FMD in the region, procedures followed to issue movement permit, presence of quarantines in the region and if traders were able to trade during these quarantines. While release and exposure assessment was done by identifying the exposure and release risk factors which were then assessed

according to the information obtained from the traders response to various risk practices using the individual questionnaires, focus group discussions and secondary data. The levels of risks were then rated as high, moderate, low or Negligible and the overall risk of release or exposure arrived at using the guidelines developed by Zepeda (1998) as illustrated in Table 1. The overall risks of release and exposure were used to evaluate the risk of a hazard occurring.

Table 1. Combination of occurrence probability of parameters considered in the qualitative risk assessment (Zepeda 1998)

Risk of release	**Risk of exposure**			
	Negligable	**Low**	**Moderate**	**High**
Negligable	Negligable	Low	Low	Moderate
Low	Low	Low	Moderate	Moderate
Moderate	Low	Moderate	Moderate	High
High	Low	Moderate	High	High

Consequence assessment was done by considering the economic and public health impact of the disease to the local economy. The economic assessment was done by considering the predominant cattle breeds in the region, cattle uses, FMD status in the region and resources used in disease control incase of outbreak while public health impact assessment was done by considering the zoonotic nature of the disease and challenges of disposing animals dying from

the disease. The risks of a hazard occurring and consequence assessment were used to estimate the risk for FMD.

Both primary and secondary data on disease outbreaks were used to determine if there is FMD virus circulating in the area, while the number of animals involved in trade, their movement patterns based on the final destination, sources, mode of transport, purpose for trade and disease surveillance activities by the veterinary department like issuing of movement permits, FMD diagnosis, vaccination coverage and response during outbreaks and trading activities such as cattle evaluation during negotiations, observing quarantines and animal isolation, time taken to resell trade animals were used in the release and exposure assessments.

This chapter has presented the description of the study area, detailed the economic activities of the population in Western Kenya, climate and location of the study area. The study units for this study were cattle markets which were purposively selected. The chapter has described in detail the data collection protocols including the types of data collected and detailed description on how the data was analyzed. The next chapter will present key findings from the study followed by a general discussion on these findings.

CHAPTER FOUR

Results

4.1Age, sex and education of respondents

A total of 252 out of 273 questionnaires were administered and completed by the respondents. Twenty one (21) questionnaires were not fully completed and were therefore not used in the final analysis. Of the 252 traders who were interviewed, they handled a total of 2,052 head of cattle within the six markets which were visited during data collection period. Kamukuywa and Kimilili were the largest markets in the area with a total cattle numbers of 721 and 677 traded weekly respectively. Amukura and Funyula had the lowest cattle population of 73 and 93 traded weekly respectively, (Table 2).

Table 2. Number of traders sampled and number of cattle they handled in selected markets

NO.	**Cattle market**	**No. of sampled traders**	**No. of cattle traded**
1	Funyula	18	93
2	Bumala	20	141
3	Amukura	15	73
4	Chwele	40	347
5	Kimilili	80	677
6	Kamukuywa	80	721
	Total	254	2052

The age of respondents was classified into three groups (young, middle and old). The young group were those less than 30 years old and they comprised 56 (22.1%) of the respondents. Middle age group were those between 30 and 50 years old, and were the majority of the traders 141 (55.7%). Those of more than 50 years of age were classified as old traders and were represented by 56 (22.1%) of the respondents. Majority of the traders 96 (37.9%) had primary level of education however combined with those with no formal education, they represented 40 (15.8%) they more than half of the traders. Therefore, cattle trade in the study area was dominated by traders with primary education and below 136 (53.7%). Traders with secondary education were represented by 85 (33.6%) of the respondents while those with above secondary education were 32 (12%) of the respondents.

4.1.1 Estimating cattle traders market share

The Lorenz curves shows Kamukuywa market as the least competitive market with 80% of the traders controlling 52% of the market share while 20% of the traders control 48% of the remaining market share. Bumala market was found to be the most competitive market as 80% of the trader controlled 73% of the market share. Generally the nature of cattle markets in Western Kenya could be described as oligopolistic which are characterized by many traders but only a few of these livestock traders were controlling trade in cattle as shown by the high values of Gini coefficients. Figure 3 presents Lorenz curves showing proportions of cattle traded by various traders in studied livestock markets.

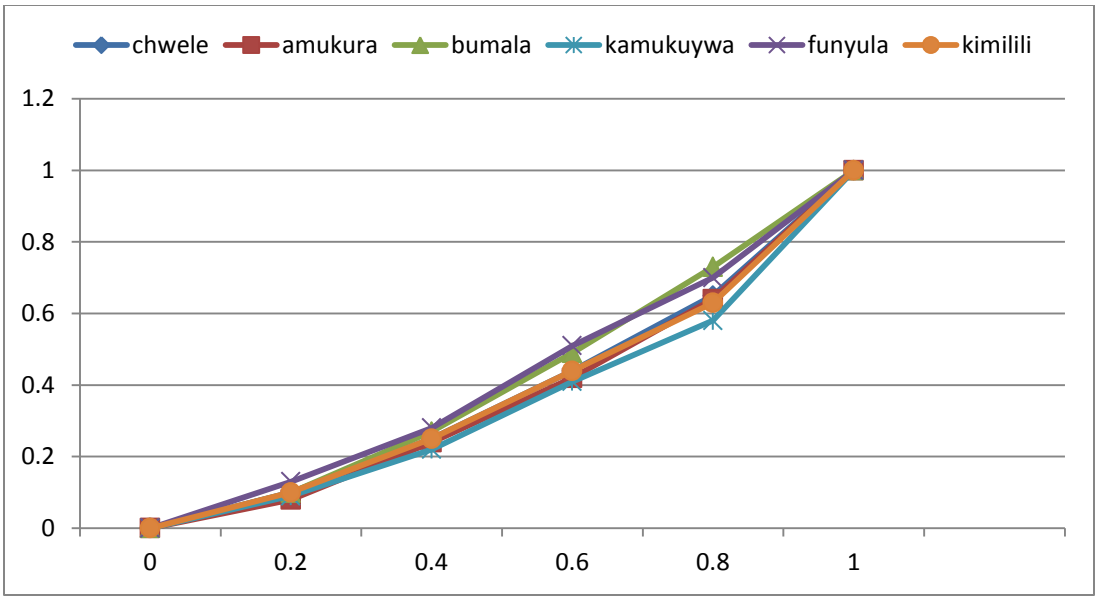

Figure 3. Lorenz curves of cattle markets in Western Kenya

4.1.2 Estimating cattle market concentration indices

These livestock markets had numerous traders. The computed values of the Gini coefficients for traders were 0.65.However this was differing from each market (Amukura 0.50, Funyula 0.51, Kamukuywa 0.71, Kimilili 0.63, Bumala 0.32 and Chwele 0.59). This shows that there was close to perfect equality of distribution or low concentration of traders within Bumala market than in other livestock markets, while Kamukuywa market had close to perfect inequality of distribution / high concentration of traders.

4.1.3 Description of barriers to entry into cattle trade

Although it was found that there were no apparent restrictions to entry and exit from cattle trading activities, the livestock traders' experience, level of education, form of partnership and availability of credit facilities, market information and mechanism of price determination seemed to significantly influence the conduct of marketing participants. Becoming a cattle trader

demanded more money (operating capital) and preparedness to undertake the risks. More than 58% of the traders interviewed indicated that they started their trade using personal savings or borrowing from friends and relatives. Because of the risky nature of the business, many traders do not obtain loans from banks and financial institutions; they also operated as sole proprietors (62%). The implication of this is that they are not able to raise enough operating capital; and livestock traders with less operating capital and in sole proprietorship were easily forced out of business due to intense competition.

Interviews with traders indicated that more than 54% were either with no formal education or with primary education and majorities (56%) were of middle age between 30 to 50years old. There were also no adequate prior access to market information, since 68% of the respondents said they had no market information, of which only 17% confirmed they had adequate market information. Cattle traders deal with undifferentiated products thus the need to develop standards to determine cattle prices. In the markets which were visited cattle prices were arrived at through visual assessment of cattle characteristic including body condition scores and consultations with other traders and brokers (53%), while these traders had more powers to set the prices of cattle than livestock farmers.

4.1.4 Estimating cattle marketing costs in Western Kenya

The cost associated with cattle marketing included that of trekking, trucking, Government taxation (council fee) and movement permits. The market price of cattle varied from market to market and depending on the time of marketing, sex, breed and body condition of the cattle; bargaining power of traders and livestock farmers. Table 3 shows the average market prices for different category of cattle in different markets. The transportation cost per animal also varied depending on the mode of transportation used by the livestock trader and the distance covered as

shown in Table 4. This could be by trekking (by self or hired person). Based on data obtained from the study, the cost of this mode of transportation ranged between Ksh. 100 to 200 per head of cattle. Some livestock traders used trucks to transport their traded cattle to and from the market; many traders from the same direction were pulling their livestock together and jointly hiring a truck to transport them. Depending on the distance they were paying between Ksh 500 to 1,000 per head of cattle. The county government also charged a fee of Ksh 100 per head for using the cattle sales yard. This was the money the county government would use to improve on market infrastructure and security. All animals purchased from any market were issued with a movement permit from the office of the local veterinary department which was costing Ksh 50 per head.

Table 3. Average cattle prices in livestock markets

Market	**Average market price per category in Ksh '000**			
	Bull	**Cow**	**Heifer**	**Bullock**
Amukura	39.33	32.07	20.87	18.47
Funyula	33.44	24.78	17.17	13.11
Kamukuywa	66.5	48.49	33.54	31.55
Kimilili	62	50.38	31.03	26.23
Bumala	49.75	41.9	24.95	14.8
Chwele	51.65	42.58	25.6	18.93
Mean	57.44	44.97	28.89	24.46

Table 4. Marketing margins and reasons for purchase of cattle

Cost per item	Amount (Ksh.)
Trekking	100 - 200
Trucking	500 – 1000
Council fee	100
Movement permit	50

4.1.5 Marketing margins and reasons for purchase of cattle

For assessment of market margins Kamukuywa market was selected as a terminal market in the study area. Generally the percentage gross marketing margins for all cattle category were high for cattle purchased from Funyula market, this was closely followed by those purchased from Amukura market. A cross all these markets, bulls and bullocks fetched higher marketing margins compared to other cattle categories (Table 5). Information obtained from discussions with focus groups and traders indicated that bull and bullocks were purchased either for slaughter or fattening. Amukura and Funyula markets were considered as primary markets located at the interior parts of the study area close to the Kenya-Uganda border, with poor infrastructures and road network. Heifers purchased in these markets were mostly for breeding purpose while cows were the old ones which were no longer considered economical in the farms, they were for slaughter. Cattle from Kimilili market fetched very little marketing margin, the reason for this is both Kamukuywa and Kimilili were transit markets therefore at the same level with almost the same prices. Cattle bought from these markets were mostly destined for slaughter in distant counties (Kakamega, Kisumu, Siaya and Nairobi). Regarding reasons for buying, 41% of the traders were buying for slaughter, 29% for resale in other markets, 21% for breeding and 9% for

fattening. On the source of animals; 22% of the livestock traders bought directly from farmers, 46% from other markets and 33% from brokers outside the market.

Table 4. Percentage of gross marketing margin of cattle markets in western Kenya

Market	Animal category			
	Bull	**Cow**	**Heifer**	**Bullock**
Amukura	41	35	**38**	**41**
Funyula	50	49	49	59
Kimilili	7	-	7	17
Bumala	25	14	25	53
Chwele	14	12	26	22

4.2 Results for risk assessment

The risk assessment results are presented following the OIE risk assessment framework which is composed of Hazard identification, Exposure assessment, Release assessment and Risk estimation.

4.2.1 Hazard identification

Information obtained from veterinary government offices indicated that there had been 2 to 4 confirmed bovine FMD outbreaks caused by SAT 1 and O strains per study sub-county within the last two years (SCVO 2016 records). While Kibore *et al*. (2013), on his study reported that bovine FMD prevalence was estimated between 52% and 100% in Western Kenya. The traders were in agreement with these, that there has been quarantine imposed in the area for the last two years though they did not specify the specific disease outbreak the quarantine was called for.

Surprisingly, 26% of these traders were able to trade and move their animals during the quarantine period. Therefore this study identified the hazard as spread of FMD causing virus from cattle markets in case an outbreak occurred in Western Kenya and an infected cow was presented for sale.

4.2.2 Release assessment

The four parameters examined in order to determine the risk of release of the FMD virus into the cattle market environment from infected animals were; Risk of an infected cattle moving through the livestock markets, survival capacity of the virus in the environment, the volume of cattle traded in the study markets and cattle marketing practices of traders in the region

4.2.2.1 Risk of infected cattle moving through the market

The risk of infected cattle moving through market unnoticed is a function of the risk of occurrence of FMD in the region. This is dependent on the following factors; prevalence of FMDV in the region; organization and efficiency of the veterinary epidemiological surveillance system and FMD vaccination coverage.

A sero-surveillance study carried out by Kibore *et al*. (2013), in Kenya indicated an overall sero-prevalence of FMD infection in bovine of around 52% in the country and about 100% in western Kenya. Also, the information obtained from government veterinary offices in the region indicated that there had been 2 to 4 confirmed FMD outbreaks per study sub-county mainly associated with SAT 1 and serotype O strains (SCVO records 2016), and that 98% of traders interviewed agreed that for the last two years, there had been quarantine in the area of study.

Information obtained from focus group discussions indicated that there was an acute shortage of veterinary staff in almost all areas and in general the veterinary departments were not well funded. Animal vaccination records obtained from government veterinary departments indicated

low vaccination coverage and sometimes it took up to six months to lift the imposed quarantine, with this lifted often without any vaccination campaign organized due to lack of funds. This delay was occasioned on the fact that there was only one laboratory with capacity to confirm FMD outbreaks in the whole country and the logistics involved to conduct a successful vaccination campaign.

4.2.2.2 Survival of foot and mouth virus in the environment

In Western Kenya, 69% of cattle farmers' practiced extensive farming of which 78% shared grazing fields with neighboring farms and 86% watered their animals from boreholes, and 74% of these farms shared these boreholes with neighboring farms. Majority of the livestock traders (61%) trekked their traded cattle to and from the markets, animal movement permits were issued without proper physical examination of the animals.

4.2.2.3 Cattle marketing practices in Western Kenya

Busia and Bungoma counties do not produce enough beef cattle for its population, which is the same case with Counties neighboring them to the south (Kakamega, Siaya and Kisumu). On the other hand counties to the north Turkana, West pokot, and Elgeyo Marakwet and neighboring countries Ethiopia and Uganda keep more beef cattle. There is a net movement of trade animals from other counties through the markets in the study area, 35% of the traders obtained their animals from neighboring counties while 24% traded on cattle from distant counties: Trans-Nzoia, Elgeyo Marakwet, West Pokot, Uasin Gishu and Turkana, and 4% traded on animals from Uganda. With regard to the destination 37% of the traders were moving animals to neighboring counties, while 27% were moving their livestock to distant counties (Siaya, Kisumu, Kakamega, West Pokot and Nairobi). This explains how cattle trade created a network for interaction of

animals from different counties, both immediate neighboring counties and distant counties and some from production systems in Uganda.

With regard to mode of transport, 61% of the traders trekked their livestock to market. These were traders who mostly did not move long distances, but they traded on animals either obtained from within the county or from neighboring counties. On the other hand 23% of the traders transported their stock on trucks, this were mostly traders who moved long distances. Trader's confirmed moving from one market to another as 55% of the traders confirmed that they would resell their animals within one to two days, while 30% of the traders reported that they would resell the cattle within 3 to 4 working days. Majority of the traders (48%) used visual examination to establish the age, sex and body condition of the animals in order to estimate its value, by so doing they palpate the animals and even opened their mouths to examine the teeth. The same trader could examine more than one animal in the market without taking any precaution on the danger of disease transmission. Although 98 % of the traders confirmed that there had been quarantines in these markets they operated in, some traders 26% often continued with trade of livestock even during the quarantines and they were still able to move their animals without movement permit. Of the six markets studied only two had a perimeter fence, none had a loading lamp and animal holding area. These markets without a perimeter fence were often used as communal grazing grounds during the non-market days.

4.2.2.4 Volume of cattle traded in the study markets

Primary data obtained from the traders indicated that there was extensive movement of animals from and to neighboring as well as distant counties for trade. On average, each trader operated a stock of 8 animals (252 traders were interviewed and they had traded a total of 2,053 animals) per market day. Approximately 37% of the traded cattle (763) were obtained from within the

same county, 34% (697) were from the neighboring county, 24% (506) were from distant counties; Trans-Nzoia, Elgeyo Marakwet, West Pokot, Uasin Gishu and Turkana, and 4% (85) were from Uganda. About 38% (780) of the cattle purchased in the markets were retained within the county, 32% (676) were moved to the neighboring counties and 29% (596) were moved to distant counties (Siaya, Kisumu,Kakamega, West Pokot and Nairobi). Based on the above, many animals are involved in trade and many were being moved long distances thus the risk of FMD spread as determined by trade volume was rated high.

4.2.2.5 Overall release assessment

Many perceived risk factors for the spread of FMD have been assessed independently and their perceived risk rated, (table 6). Using the matrix proposed by Zepeda (1998), it was concluded that the risk of FMD virus release from infected animal to the environment was a function of combining of risks relating to the risk of an infected animal going through the livestock market which was rated high, the risk of FMD virus survival in the environment which was rated high, risks due to traders marketing activities were categorized as high and risk due to volumes of traded cattle was high; thus the risk of traded cattle contaminating the environment with FMDV was rated as high.

Table 5. Summary of release risk factors assessment

PERCEIVED RISK FACTOR	ASSESSMENT OF PERCEIVED RISK FACTOR	RATING OF PERCEIVED RISK
FMD prevalence	100% (kibore et al 2013)	high
confirmed FMD outbreaks	2 to 4 per sub-county	high
veterinary network	good structure	low
veterinary staffing	understsffed	high
veterinary funding	underfunded	high
vaccination coverage	low turnout	high
virus elimination	quarantine/ no destruction	high
share of grazing fields	78% shared	high
share of watering point	74% shared	high
use of non moving water	84% water from boreholes	high
transport of trade animal	61% trekked	high
issue of movement permit	no physical examination	high
time taken to resale animals	1-2 days 55%,3-4 days 30%	high
estimating animal value	48% eye (palpation, dentition)	moderate
bargaining	shaking of hands	moderate
trading during quarantine	26% have traded in last 2 years	moderate
quarantining of animals from market	97% did not	high
buying animals from market	45% of traders buy from markets	moderate
market structere (fence, holding ground	67% had no fence	high
cattle moved from neghboring county	34% (697)	high
cattle moved from distant counties	24% (506)	high
cattle moved from Uganda	4% (85)	low
cattle moved to neighboring county	32% (676)	high
cattlemoved to distant counties	29% (596)	high

4.2.3 Risk of exposure of cattle to foot and mouth virus

The parameters considered in determining the risk of exposure were; risk of infected animal making susceptible contacts, the risk of market animals making infectious contacts, risk of cattle from markets not being quarantined and risk of FMD transmission within and between the farms.

4.2.3.1 Risk of infected cattle making susceptible contacts

Herd immunity is a function of vaccination coverage and vaccine efficacy. While vaccination coverage depends on vaccination campaign efficiency and commitment of farmers to take their cattle to the assigned vaccination centers. Information obtained from the Veterinary Departments in the study areas indicated that they don't have enough resources to carry out regular vaccinations against FMD. Traders confirmed that sometimes vaccinations were carried out long after the outbreaks had been contained. Additionally, farmers were required to pay for vaccination services whenever they were carried out, and since their animals were not always sick at the time of vaccinations they did not see the value of this intervention. Generally, there was no commitment from livestock farmers to take their animals for vaccination, hence vaccination coverage was low. Based on the fact that there are seven immunologically distinct serotypes each with numerous strains and on the fact that infection with any one of the serotypes does not confer immunity of the other serotypes, a large proportion of cattle population were susceptible to the disease. Based on the above evidence that there were no regular FMD vaccinations, low commitment from livestock farmers to take animals for vaccinations and with many FMD serotypes the proportion of FMD susceptible animals in western Kenya was considered to be high.

4.2.3.2 Risk of marketed cattle making infectious contacts

Within cattle markets, animals were moved long distances from different production systems. Data obtained from traders indicated that 37% of the traders who brought animals to study markets were from within the county while 62% were from outside the county of which 4% were from Uganda, 24% from distant counties and 34% were from neighboring counties. However, not all these animals remained within the study counties as 64% of the traders were destined to other counties and 41% of all the traders were buying animals for slaughter. This is an indication of many animals being moved from far distances for trade and a significant reduction of these animals within the study counties as most of them were on transit to other counties and even some were for slaughter.

In the market, each trader or a group of traders grouped their animals together as they bargained with buyers. There is high possibility of a sub-clinical FMD infected animal getting to contact with susceptible animals in the market. It was also common to see bull and bullocks mounting cows and heifers. Considering the above facts that many animals were being moved from different counties for trade, many of these animals also passed through study markets to other destinations, although many animals which were bought from this markets were for slaughter, there was high risk of contamination of in-contact animals and therefore the risk of encountering an infectious contact was rated as high.

4.2.3.3 Risk of cattle from market not being quarantined

Most traders (97%) did not isolate traded animals from other animals at their farms. Even farmers who obtained animals from the market they don't isolate them from other animals they had in their farms. Animals purchased from the markets were grazed, watered and penned together with other animals in the farm without proper examination and observation for disease.

If any of the animal brought into the farm was a carrier or had sub-clinical FMD it would contaminate the whole farm and infect all susceptible animals there. In the study area animals were grazed communally in open spaces, watered on communal boreholes or at public watering points along rivers and most farms did not have permanent fences separating them. It was not possible to completely isolate animals of one farm from the other farm. Effective quarantine needs complete restriction of animal movement, while being examined for development of diseases; proper restraining facilities such as a fence and trained personnel were needed. This was not possible at farm level. Some livestock traders (26%) reported that they were able to trade during quarantine periods, while others were able to move cattle from one market to another through quarantine areas.

4.2.3.4 Risk of foot and mouth disease transmission within and between farms

The risk of FMD transmission to susceptible animals was assessed by considering the mode of virus spread and characteristic in terms of replication, survival in the environment and infectiousness. Foot and mouth disease virus spreads rapidly through the movement of infected animals or mechanically through fomites such as contaminated vehicles, visitors, animal handlers, clothing, feeds, and veterinary inputs. Based on the above facts the risk of FMDV transmissions was rated high.

4.2.3.5 Overall exposure assessment

All the perceived exposure risk factors were considered independently and their risk rated (table 7), and the risk of exposure resulting from the combination of the four categorized parameters examined: risk of an infected animal making susceptible contacts (high), Risk of marketed animals making infectious contacts (high), Risk of cattle from the market not being quarantined

(high) and risk of FMD transmission within and between the farms (high), was thus considered to be high.

4.2.4 Magnitude of the consequences

An outbreak and spread of FMD in western Kenya has high economic impacts to the local economy, but negligible impacts on public health since the disease does not affect humans. The indigenous breed dominates the animal population in western Kenya, they are mainly kept for beef and little milk. Farmers do not loss animals to the disease, but when livestock markets are closed, traders cannot sell or buy, thus they lose sources of their dairy income. Furthermore, the government would spend a lot of resources for ring vaccinations to control the outbreak. The magnitude of the consequences was thus rated as moderate.

The overall risk assessment for occurrence of the hazard (FMDV spread) in western Kenya was considered to results from the combination of risks of release considered as high and risks of exposure considered as high. Thus the risk of occurrence was considered to be high. The overall risk was assessed as the combination of the risk of occurrence (high) and of the consequences of occurrence (moderate), thus rated as high (Figure 4).

Table 6. Summary of exposure factors assessment

Perceived risk factor	Assessment of risk factor	Rating of risk factor	
Vaccination coverage	Low coverage	High	
Farmer commitment to vaccination	Low commitment	High	
Virus serotype	Five serotypes in study area	High	
Virus strains	Many	High	
Virus cross immunity	No cross immunity	High	
Animal movement	Many animals long distance	High	
Animal contacts	High	High	
Animal evaluation	Physicaly / Palpation	Moderate	
Fencing of cattle markets	2/6 Fenced	Moderate	
Quarantine of trade animals	No quarantine	High	
Grazing management	Extensive at open spaces	Moderate	
Farm fencing	No permanent fence	Moderate	
Trade during quarantine	24% traded	High	
Time to resale	85% Within 4 days	High	
Virus replication	Rapidly	High	
Virus spread	Rapidly	High	
Virus stability	Very stable	High	

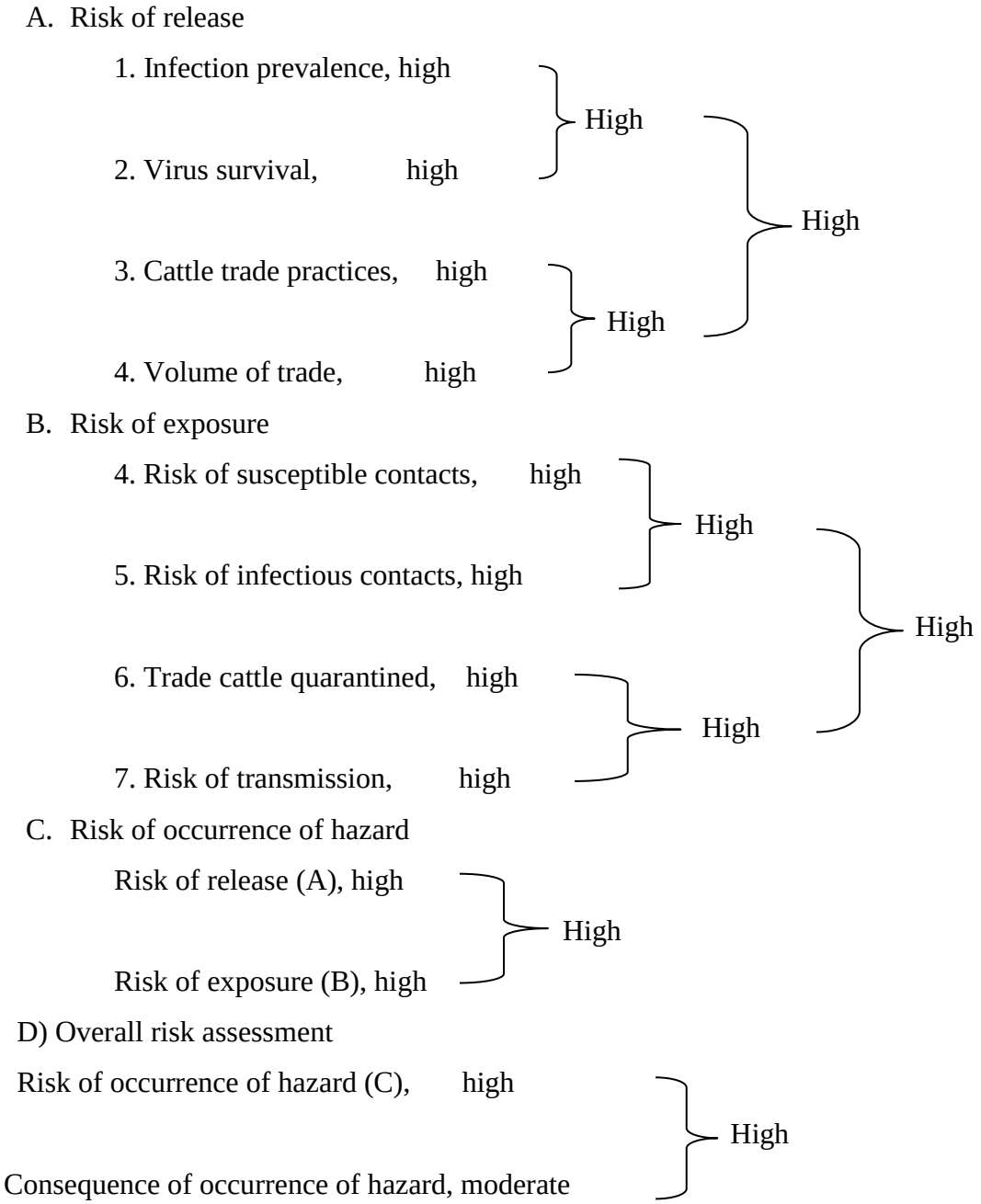

Figure 4. Risk of occurrence of various risk factors using descriptive scale and classification matrix defined by Zepeda (considering two factors at a time)

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

The data collection methods used in this study had been used by other epidemiological survey studies, of pig markets in Nigeria (Ajala *et al*., 2008), cattle markets in Kenya (Onono *et al*., 2015) and risk assessment study in Danish swine population (Bronsvoort *et al*., 2008). The livestock markets which were selected for the study were primary and secondary markets; and no terminal market was selected in the region. The secondary markets visited were transit markets to terminal markets in major urban areas in western Kenya and Nairobi. In Kenya the market of beef cattle and meat products have been reported to be in urban and peri-urban areas (Farmer *et al*., 2012).

This study report that cattle trade in western Kenya was dominated by men of middle age and of lower education levels, these were the active members of the society whose main source of income was trade, cattle markets structure is also reported as being oligopolistic: meaning there were fewer traders who dominates the cattle trade in the study markets. A similar study in Nigeria also revealed that pig marketing was highly concentrated (Ajala *et al*., 2008), while in Kenya a study of transit cattle markets reported that a few traders controlled large market share of the business (Onono *et al*., 2015). Transport cost constitutes the highest proportion of the marketing cost incurred in the region, this is in agreement with the high transport costs reported within agricultural markets in Kenya by previous studies (Osterloh *et at*., 2003, and Onono *et al*., 2015). Further analysis of the selected markets revealed that lack of capital and adequate market information were the barriers to entry into cattle business. This could mean that few traders have enough operational resources and market information, these few traders may form cartel like

groups which can control the market to their advantage. There is a possibility of existence of alliances between traders which are based mainly on kinship friendship and capital. This affects the performance of markets in terms of access to market information and price setting. This will exploit the farmers and discourage them from cattle farming as they cannot be able to meet the high costs of farm inputs and get extra money for their family use. This eventually will affects food security, nutrition, economic and social well-being of families depending on cattle farming and trade within the region.

High operating capital was reported as a barrier to entry into pig business in Nigeria, to the contrary the same study reported free flow of market information (Ajala *et al.*, 2008). Lack of free flow of market information could be an indication of lack of cattle market integration in the region, lack of integration of agricultural markets have been reported in Kenya (Onono *et al.*, 2015). However more studies are needed to establish why there is no adequate flow of market information and if indeed there are cattle market integration which was not done by this study.

The overall results for qualitative risk assessment in this study supports the hypothesis that cattle marketing activities in Western Kenya have a potential effect on the transmission of FMD within connected farms and systems. Though the approach used in this study has limitations it has advantage of being simple and based on a well described and acceptable methodology as described by OIE. It is a preliminary step in the process of building more sophisticated qualitative or quantitative risk models. All the markets selected for the study lacked the basic facilities and adequate stuff for screening cattle diseases making it possible for infected animals to go through the market un-detected. This is especially so when dealing with cattle traders whose main activity is moving from one market to another while buying and selling. It is a common practice for traders to move cattle from one market to another in search of better prices

in this region. Majority of the traders were able to resell their trade cattle within five days while the incubation period of FMD is up to 14 days. This implies that an infected animal could be moved in more than one market before showing clinical signs of the disease. The cattle traders don't take much consideration of the immunity status of the cattle they handle and there is lack of bio-security measures in their farms and the markets they visit which is a concern for the success of FMD control.

Lack of enforcement of restrictions for animal movement and trade on non-vaccinated animals are some of the factors which enable FMD infected cattle to reach the market thus making them a hub of disease transmission. Movement permits were being issued as a formality in the markets visited as opposed to being a disease surveillance tool. Cattle were not being examined prior to issuance of movement permit and not all traders obtained the permit yet they were able to move their animals. The veterinary network in Kenya is well structured and covers the whole country. However shortage of both staff and funds limits its capacity with respect to veterinary disease surveillance, reporting and control of notifiable diseases in the area. This has the potential to cripple its ability to carry out effective disease surveillance. For instance disease quarantine could take up to six months to be lifted, this discourages traders whose only source of income is buying and selling of cattle and in the process they find ways to violate the quarantine lawthus putting the cattle population at risk of spread of communicable diseases. Traders confirmed as being able to trade and move animals when there was quarantine, an indication of lack of adequate reinforcement. The movement of FMD infected cattle to the market has been reported as a risk factor in the FMD virus spread during the outbreaks in Britain and Netherland (Donnelly *et al*., 2001).

Information obtained from Veterinary Offices on FMD outbreaks indicated that there were high incidents associated with SAT 1 and serotype O FMD virus strains in the region. Despite all this cattle vaccinations against FMD were reported to be irregular and characterized by poor turnout. This was attributed to the fact that farmers paid for these vaccinations and most times, vaccinations were carried out long after the outbreaks had been contained, and farmers did not see value for this intervention. Due to poor funding whenever there was an outbreak it took time for the veterinary department to collect samples send them to the only FMD laboratories located in Embakasi, Nairobi for confirmation and serotype identification. The procurement of vaccines would delay the response time and at times even after the vaccine had been procured there would be further delay due to logistics of assembling the vaccination teams and transportation logistics. With poor turnout there is low vaccination coverage which results to low herd immunity and therefore a large susceptible population.

Considering the fact that FMD virus is in large volumes and in high titer in saliva and respiratory secretions, it is stable in these secretions with a short incubation period of 1 to 12 days, and has many strains with no cross immunity the disease is highly infectious and spreads rapidly within susceptible population makes it difficult to eradicate the virus from the market environment. The cattle markets being oligopolistic means there is no perfect competition, there are a group of traders who are struggling in this markets, they may keep changing their activities in these markets to remain in business. All these together with the many risk trade practices and activities which have been highlighted by this study and the fact that there are challenges in disease surveillance and control in the region as reported makes cattle markets a risk hub for the spread of FMD.

5.2 Conclusions

- Cattle markets in western Kenya have an oligopolistic structure with an estimated Gini coefficient of 0.65. Bumala market was the most competitive with a Gini coefficient of 0.32 and 80% of the traders controlling 73 % of the total market share, while Kamukuywa market was the least competitive with a Gini coefficient of 0.71 and 20% of the traders controlling 48% of the market share.
- There are positive gross marketing margins in all study cattle markets and across all cattle categories. However bulls, bullocks and animals from primary markets (Amukura and Funyula) had higher gross marketing margins.
- Transport was the highest cost incurred by traders while lack of enough capital and adequate market information were the main entry barrier to cattle trade in Western Kenya.
- Trade on non-vaccinated cattle, unregulated cattle movement, inadequate stuffing of veterinary department, cattle price setting practices, and low levels of bio-security observed within the markets, farms and by traders, were the risk factors identified for spread of FMD through cattle markets
- There is high risk for FMD spread through cattle marketing activities.

5.3 Recommendations

- This study recommends that the government and other relevant institutions should encourage the use of weights as a measure of animal value to reduce exploitation of farmers by traders. This can be achieved by setting up of weighing scale at specific locations in the market, some fee can be charged for their use or the council fee can be increased to accommodate this cost.
- This study also recommends that farmers and traders be encouraged to form organized marketing groups to facilitate easy access to market information and credit facilities. These

groups can be registered and licensed to operate within a defined area. They can be taught to keep records of animal's movement and the roles they play in animal disease control.

- The Veterinary Department should be adequately funded to improve on its capacity to conduct adequate and efficient epidemiological surveillance, control animal movement, create awareness among traders and farmers on roles cattle trade play on spread of FMD and to conduct a subsidized FMD strategic vaccination program using a quadrivalent vaccines to improve on vaccination coverage to at least 85% of the cattle population thus improving on herd immunity and reducing the virus survival on the environment.
- Regulations on issuing of cattle movement permits and cattle movement policy needs to be developed so that animal movement can be tracked to improve on disease surveillance.

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APPENDIXES

Appendix 1: Cattle traders interview schedule

This questionnaire is prepared to assess the cattle trade activitiesin Western Kenya

Name of enumerator----------Name of market ---------- Date----------

Section one: Characteristics of the respondent

1. Age □ 1. <30 □2.between 30 and 50□3 .>50

2. Educational status □1. No formal education □2. Primary education

3. Secondary education □4. Above secondary

3. How long have you been in trading (cattle)? □1.<1 year □2.1-3 □ 3. >3 years

Section two: Trader's activities

4. If you are buying cows, what is your purpose of buying?□ 1.Resale □ 2. Butchery

□3.Breeding □4. Others (specify)--------

5. If you are selling where do you purchase from?□ 1.Farms □2.Market □3.from traders

6. How many cattle did you buy/purchase in this market? …….

Section three: Pricing practices

7. What are the cattle prices in this market? 1. Mature bull……. 2. Mature cow……

3. Heifes…… 4. Bullock

8. How do you determine price? □ 1. Live weight basis □ 2. Eye estimation □3.Both

9. In your opinion, who have more power to set the price in this market?

□1.Farmers □ 2. Traders □ 3. Government □4. Market forces

Section four: Disease control practices

10. In the last two years has there been a quarantine in the markets you visit?

□1.yes□2. No

11. Did you buy or sale cattle during this quarantine period? □1.yes□2. No

12. Which market services did you use in this market? (More than one answer is possible)

□1.Veterinary services □2.Watering service □3.Security service □ 4. Banking services

13. At your farm do these cattle for trade graze and drink separately from other cattle in the farm? □1.yes□2. No

14. At your farm do these cattle for trade share grazing fields and watering points with cattle from neighboring farms?□1.yes□2. No

Section Five: Credit Services

15. What are your sources of working capital to run this business? □1.Own □2.Friends or relatives □3. Bank borrowing □4 Micro-finance borrowing □5. Others (specify)…

Section six: Animal movement

16. What mode of transportation do you use? □1.Trekking □2.Trucking □3.Both

18. What is the final destination of cows bought from this market? □1.In the county □2.Neighboring county □ 3. Distant county

19. What is the origin of the animals you brought to this market □1. Within the county □2. Neighboring county □3. Distant county □4. Uganda

20. How long does it take you to reach the resale market? □1.one to two days □2.Three to four days □3. Above five days

Section nine: Marketing costs

21. Did you know the market price of cattle before you sold/bought? □1. Yes □2. No

22. Did you pay the council fee for cows you purchase? □1. Yes □2. No

23.Did you obtain a movement permit from this market? □1.Yes □2. No

24. What other marketing costs do you incur in this business?

Appendix 2: Check list for focus group discussion with market participants

1. How are the cattle prices determined?

2. What are the challenges faced by veterinary officers in disease surveillance?

3. What is the structure of veterinary department in Kenya?

4. Averagely how many cows come to this market on main market day?

5. Averagely how many traders attend this market on main market day?

6. What is the origin of cows traded in this market?

7. What is the destination of cows bought in this market?

8.When was FMD last reported in this region?

9. What is the main means of transportation used by traders?

10. How many FMD outbreaks have been reported in this region for the last 2 years?

11. How are the FMD outbreaks confirmed and reported?

12. How is movement permit issued at the market?

Appendix 3: Turnitin Originality Report

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