ADDIS ABABA UNIVERSITY
COLLEGE OF VETERINARY MEDICINE AND AGRICULTURE

RISK ASSESSMENTS OF PRIORITIZED TRANSBOUNDARY DISEASES IN BORENA BULLS MARKET CHAIN AND ITS IMPLICATION FOR INTERNATIONAL TRADE

BY

GEZAHEGN ALEMAYEHU AYALEW

JUNE, 2012

DEBRE ZEIT, ETHIOPIA

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A thesis submitted to the College of Veterinary Medicine and Agriculture Addis Ababa University in partial fulfillment of the requirements for the Degree of Master of Science in Tropical Veterinary Public Health

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LIST OF ABBREVIATIONS

BSE	Bovine Spongiform Encephalopathy
CBPP	Contagious Bovine Pleuropneumonia
C-ELISA	Competitive Enzyme Linked Immunosorbant Assay
CFR	Case Fatality Rate
CI	Confidence Interval
CSA	Central Statistical Agency
DNA	Deoxyribonucleic Acid
EFSA	European Food Safety Authority
ELISA	Enzyme Linked Immunosorbant Assay
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization
FMD	Foot and Mouth Disease
FMDV	Foot and Mouth Disease Virus
GDP	Gross Domestic Product
LMM	Livestock and Meat Marketing
LSD	Lumpy Skin Disease
LSDV	Lumpy Skin Disease Virus
Mmmsc	*Mycoplasma mycoides* subsp. *mycoides* small-colony type
MOARD	Ministry of Agriculture and Rural Development
NAHDIC	National Animal Health Diagnostic and Investigation Centre
NVI	National Veterinary Institute
OIE	Office International des Epizooties
PAR	Population at Risk
PE	Participatory Epidemiology
PPR	Peste Des Petits Ruminants
PRA	Participatory Rural Appraisal
RVF	Rift Valley Fever
SAT	Southern African Territories
SNNP	Southern Nation Nationalities and People’s Region
SPS	Sanitary and Phytosanitary
SPSS	Statistical Package for Social Science
SSI	Semi-Structured Interview

TADs	Transboundary Animal Diseases
USD	United States Dollar
WTO	World Trade Organization
$\chi 2$	Chi –square

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ABSTRACT

Risks of introduction of transboundary animal diseases (TADs) such as foot and mouth disease (FMD), lumpy skin disease (LSD) and contagious bovine pleuropnumonia (CBPP) through traded Borena bulls to market chain and its consequences were assessed. The assessment used the framework that has been recommended by the World Animal Health Organization (OIE) for risk analysis. Likelihoods for release and exposure were estimated by a qualitative scale ranging from negligible to very high. Whereas, the consequences resulted from diseases occurrences were assessed quantitatively. Fattened bulls intended to export originated mainly from Borena pastoral system where these transboundary animal diseases were endemically established. The likelihood of the introduction of TADs to the market chain through traded Borena bulls is found to be high for FMD and LSD and medium for CBPP. The probability of bulls in the feedlots becoming exposed to FMD virus and *Mycoplasma mycoides* subsp. *mycoides* small-colony type (*Mmm*SC) bacteria is also high and very high for LSD virus. Biological consequence such as prevalence and incidence and economic loss were assessed. From the total of 11189 bulls observed during outbreak investigation of LSD in six sites of feedlot operation in and around Adama, 681(6.1%) and 204(1.8%) bulls were found affected and dead with LSD, respectively. From the total of 38187 bulls examined for FMD and CBPP antibodies, 5536(14.5%) and 150(0.4%) were found positive and subsequently rejected from international market in 2011, respectively. The total annual (2011) economic loss due to prioritized TADs was estimated to be 4,081,972.2 USD which is equivalent to 69,230,245.12 ETB (1USD= 16.96 ETB). The analysis of matrix scoring showed strong agreement (W=0.837 to 0.989; P=0.000) among the 10 informant groups for the disease indicators. The introduction of those diseases to the market chain of Borena bull for export is discussed in terms of international markets and trade disruptions. The risk estimates for all prioritized transboundary diseases are greater than negligible, therefore, transboundary diseases prevention strategy along the chain should be carefully considered by the Ethiopian veterinary services.

Key words: Borena Bulls, Export, International Trade, Market Chain, Risk Assessments, Transboundary Animal Diseases

1. INTRODUCTION

Ethiopia is a resourceful country bestowed with the largest livestock resource in the Africa continent (FAOSTAT, 2007) and the cattle population is estimated to be 53.4 million (CSA, 2011) with the potential to export substantial numbers of live animals and their products. Livestock is central to the Ethiopian economy, contributing for 20% of the GDP, supporting the livelihoods of 70% of the population and generating about 11% of annual export earnings (SPS-LMM, 2010). However, the livestock sub-sector's contribution to the economy and foreign currency earnings in particular, is very low as per the country expectation and potential of the sectors. Some of the major factors contributing to the poor performance of the livestock sub-sector include the prevalence of highly contagious transboundary animal diseases (TADs) such as foot-and-mouth disease (FMD), lumpy skin disease (LSD) and contagious bovine pleuropneumonia (CBPP). These diseases continue to hinder international trade in live cattle and their products seriously in an era of globalization. Public concern is growing regarding the rapid transboundary spread of animal diseases through animals and animal products have forced importing countries to apply strict measures so that animals and their products exported should meet international sanitary phytosanitary (SPS) requirements.

Live cattle export from Ethiopia is largely feedlot-based in which it involves value adding processes for three to four months in the feedlots. The export live cattle marketing chain actors are those who transact cattle as they move along the chains from the primary producers to the end users. In these chains, there is a lack of transmission within the marketing system of key information regarding attributes such as quality and health. Furthermore, actors along the chain lack consensus on export requirements in which cooperatives emphasized on breed and color, brokers and traders emphasized on size and feedlots operators are more concerned about condition and health (GebreMariam *et al.*, 2010). These indicated that chain actors are not adequately informed of the importance of establishing source of origin, traceability mechanisms, and related certification processes for marketed animals. Furthermore, they do not yet appreciate the importance of issues related to food quality, the link between animal health, meat quality and safety, and why documentation is fundamental in enhancing competitiveness in the global market. As a result, live cattle exported from Ethiopia fail to compete in international market especially in those importing countries having more strict

SPS measures. The repeated bans imposed by importing countries on live cattle export trade of Ethiopia signify a lack of confidence in the country's export systems.

Animal diseases could be spread through production and marketing chains. Movement of infected animals is considered to be the main risk factor for the introduction of many infectious diseases, including TADs, into disease-free areas. Networks and linkages in value chains that link production systems, markets and consumers constitute a "contact network" for contagious diseases and provide opportunities for transmission of disease within and between sectors. Structure of the livestock sector and people involved in the market chain influence the spread of diseases along the chain. Therefore, these chains, or 'networks', must be taken into account in planning strategies for disease prevention and control. This process needs to recognize that within livestock market chains there are many stakeholders who are affected differently by animal diseases and their control. Some are affected by animal disease risk; others may be able to influence risk, whilst some may be affected by prevention and control measures. Ideally, any interventions should be proportionate to the risk and impact faced by each stakeholder, otherwise compensatory mechanisms and/or sanctions may be needed to assure compliance and equity.

Sustained control of contagious disease can be achieved by reducing the risks of disease transmission in the livestock population, in addition to quick disease detection, containment and response. In order to reduce risks, understanding of the risks and the factors that determine them (risk analysis) is required. Detailed knowledge about the livestock populations and about the behaviour of the people involved in all stages of livestock production and marketing (value chain) is an essential component of risk analysis. This knowledge can be developed and enhanced through value chain analysis (FAO, 2011).

The use of market chain analysis with risk analysis allows identification of risk hotspots in the livestock sector. These risk hotspots should then be examined to determine how control measures could then be targeted at them. Market chain analysis can further provide information about the feasibility of control measures and potential impact of control measures on the chain actors (things will be changed in the value chain) and risk analysis can provide estimates of the effect of measures on overall disease risk (the incremental level of control likely to be achieved). This is often referred to as a 'risk-based' strategy (Taylor *et al.*, 2010).

To improve the competitiveness of cattle export from Ethiopia an active strategy to improve cattle health, safety and quality requirements of importing countries are crucial. This is achieved mainly by reducing disease risk in value chains to acceptable level. These involve changes in the behavior of the people involved in the market chain. If such a strategy is to be effective, the different people involved will have to be convinced of its necessity and validity of TADs prevention and control along the chain. Consequently, intervention along the chain should be based on transparent and evidence-based planning and decision-making which requires methods to analyze the risk of these diseases in the chains that link production systems, markets and consumers. Even though some value chain analysis were undertaken in economic aspect livestock marketing, information on risk of transboundary diseases such as FMD, LSD and CBPP in livestock market chain for export from Ethiopia in general and Borena live cattle market chain for export in particular is highly scanty. Hence, there is a need for risk assessment of those diseases in Borena bull market chain for export. Therefore, the aim of this study was to assess the risk of introduction of prioritized TADs in Borena bull market chain for export.

The specific objectives of the study were:

- To assess the likelihood of release of prioritized transboundary diseases into feedlots by infected Borena bulls.
- To assess the probability of exposure of bulls to prioritized transboundary diseases in feedlots
- To assess the consequences (biological and economic) resulted from the diseases occurrence.
- To evaluate the perception of the market chain actors towards the risks.

2. LITERATURES REVIEW

2.1. Risk analysis

Risk is defined as the likelihood and magnitude of an adverse event (Ahl *et al*., 1993). An important risk for the livestock production sector is the introduction of a contagious animal disease into an area free of disease and its epidemiological and economic consequences (De Vos and Saatkamp, 2000). Risk analysis is a formal method of dealing with hazards and risks. Risk analysis makes systematic use of the available information as an aid to decision making. To date, the main application of risk analysis in the animal health field has been stimulated by the agreement on the application of the sanitary and phytosanitary measures (the SPS Agreement) of the World Trade Organization (WTO) (WTO, 1994). A formal framework for risk analysis in veterinary science was developed specifically to provide an objective method for making decisions on inter country trade (OIE 2004a and b), but it is also applicable to other areas of animal disease control and, more widely, to other risky decision contexts. The risk analysis process recommended in the OIE International Animal Health Code consists of four components (Fig. 1).

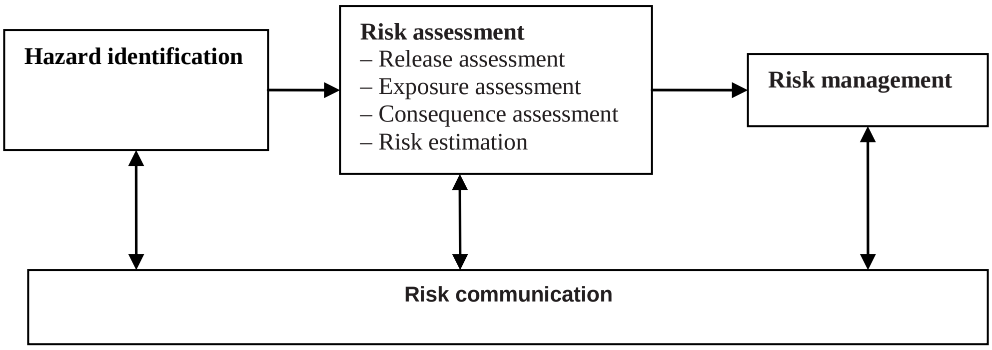


Figure 1: The Four components of risk analysis

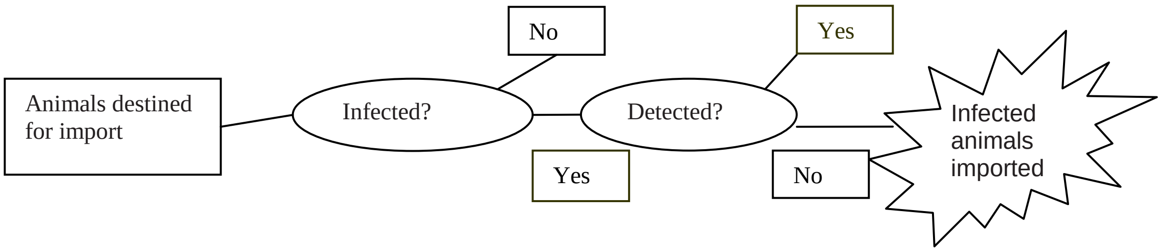
2.1.1. Hazard identification

A hazard is something that is potentially harmful to humans, animals, plants or the environment. A pollutant that may contaminate the environment is a hazard (OIE, 2011). A pathogenic organism that may be present in a piece of meat or infected animal is a hazard. The existence of a hazard is a prerequisite for the issue of risk to arise. Furthermore, for risk to be an issue there must be several possible outcomes associated with the hazard, of which at least one is unwanted/ harmful. An unwanted/harmful outcome is defined as an outcome that brings damaging consequences. Movement of live animals to diseases free areas may lead to the introduction of an animal that is infected with a certain pathogen (the hazard). Such movement may lead to a variety of outcomes: no onward spread of infection; onward spread of infection to local livestock resulting in an epidemic; a self-limiting outbreak; or cross-border spread. Of key importance is that there is uncertainty about which particular outcome will occur there is an element of chance (or risk). This is where the risk question arises. To proceed to risk assessment from hazard identification requires the framing of a "risk question" about the hazard and the potential harm (unwanted/harmful outcome) it may cause (FAO, 2011).

2.1.2. Risk assessment

Animal health regulatory officials are increasingly interested in applying risk assessment techniques to international trade issues. Risk assessment is an evaluation of the likelihood of an adverse event occurring and the magnitude of impact should it occur. There are four major steps in carrying out a risk assessment (OIE, 2011) these are release assessment (probability of release from the source); exposure assessment (probability of exposure to the hazard); consequence assessment (biological consequences such as prevalence and economic consequences, etc.) and Risk estimation (which consist of combining the release, exposure and consequence probabilities).

Risk pathway analysis is the main tool used in risk assessments. The risk pathway describes all the stages in the biological process that lead to the unwanted outcome. A risk pathway is a series of conditions that must be met, or events that have to occur, in order for the unwanted outcome to occur. Risk pathways explicitly show the chain of events that must occur for the final unwanted outcome to happen. Each event in a risk pathway has a non-zero and uncertain probability of happening. Risk assessment involves assessing the probability or likelihood of passing each step, and then to combine these into an overall likelihood. It is easiest to begin by sketching a risk pathway on paper, as a diagram showing all the steps on the pathway. Figure 2 illustrates the pathway corresponding to a simple import risk assessment. The diagram shows that the first step to consider is whether or not animals destined for import are infected. Secondly, if animals are infected, they may or may not be detected by a pre-export test (if not detected then the unwanted outcome has occurred). Constructing the risk pathways can be a valuable participatory and discursive process in risk communication.



Source: FAO, 2011

Figure 2: Pathway for a simple import risk assessment

In order to make any estimation of probability of pathogenic agents release and exposure of animals and humans along the chain, it is necessary to understand and assess the factors that influence the probability of an event happening. Steps along the pathway will normally have many risk factors associated with them and the final estimate of risk (as defined by the risk question) will be formed by considering how all these factors combine and act together. Descriptive information and/or quantitative data are needed on all of these factors. Consider a common example variable the probability that an animal destined for movement or import is infected with a specific pathogen. This probability will be calculated in terms of prevalence of disease, which in turn depends on incidence and duration of infection; incidence may vary with region, breed or age. The probability of an infected animal being prioritized for import will also depend on whether or not the selection process is random (maybe only breeding females of a particular age are imported). Therefore information must be collected on all of these factors and combined in the relevant way.

Risk assessments are usually divided into quantitative and qualitative risk assessments. However, this division represents two extremes of what in reality may be a more continuous range (e.g. semi-quantitative assessments are also common). At the quantitative extreme, the probability of a hazard occurring is calculated using probability calculations. It needs to estimate probabilities at each step of each and every risk pathway (OIE, 2004b). Qualitative analysis results in judgmental categorization of likelihood of an unwanted outcome occurred (e.g. very low, low, medium and high) (EFSA, 2006).

Risk assessment also involves estimating both the likelihood that an unwanted outcome will occur and the magnitude of the impact of this occurrence. To arrive at a final estimation of risk, some account must be taken of the impact of the unwanted outcome. The overall level of risk is defined as a product of the likelihood of an unwanted outcome is occurring and the impact resulting should it occur (the consequence). This estimate may be either qualitative (in words) or quantitative (a numerical estimate). Examples of consequences include direct consequences (animal infection, disease and production losses, public health consequences) and indirect consequences (surveillance and control costs, compensation costs, potential trade losses and adverse consequences to the environment) (OIE,2011).

2.1.3. Risk management

Risk management is the process of identifying and implementing measures which can be applied to reduce risk to an acceptable level and documenting the final decision (North, 1995**)**. The objective of carrying out risk analysis is to search for ways to prevent disease transmission throughout production and market chains i.e. to find ways to manage (reduce) the risk. Risk reduction creates awareness and takes into account all the ways in which disease can spread and takes every practical measure to minimize the risk of disease spreading. This includes spread both into and out of farms and at every step of the value chain, wherever disease agents may be found. Risk management utilizes risk assessment results in a judgments process to balance potential benefits against assessed risks, to reach decisions on acceptable risk and to formulate policy (risk reduction/control strategy) on that basis. Cost-benefit and/or risk-benefit analyses may be included in the decision-making process (FAO, 2011).

Risk management should be undertaken as a structured and systematic process encompassing all aspects of risk analysis. Risk management entails identification and implementation of risk reduction/control measures. The entire process can be broken down into the series of activities such as risk appraisal (using the output from risk assessment), option appraisal (including impact assessment), implementation of chosen risk reduction measures and monitoring and evaluation (FAO, 2011; OIE, 2011).

The general objective when managing risk is usually expressed as attaining “acceptable risk”. But what is an acceptable risk and according to whom is it acceptable? This is a very difficult question because what is considered an acceptable risk to one person, group of people or country may not be considered acceptable to others. Many factors affect agreement regarding the acceptability of any given level of risk, particularly because “those who bear the risk are often not those who receive the major benefits”. However, negotiating about whether a risk is acceptable requires common recognition of the magnitude of the risk on the part of all those involved in the negotiations. This requires an assessment of that risk by means of a methodology that is agreeable to all parties. It is in order to ascertain what is acceptable in the situation under analysis that risk communication, the fourth element of risk analysis, must begin at an early stage of the risk analysis process. The acceptability of a risk then depends on different stakeholders’ perceptions of the balance between the assessed risk and the potential benefits of taking the risk and/or the cost of risk mitigation measures.

Risk management is usually the responsibility of administrators, often in government but sometimes in the private sector, in response to regulations established by national or international authorities. Risk managers must consider not only scientific factors, but also the legal requirements that define admissible alternatives, and they must examine not only the potential consequences of their decisions for animal health, but also the economic, political and social consequences of their decisions. In many ways, therefore, risk management is also an art based on judgment, rather than a formula to be applied (North, 1995**)**.

2.1.4. Risk communication

Risk communication means an open information exchange between all those affected by both the risk in question and the decisions taken (the stakeholders), before the final policy decisions are taken. It should be started as early in the risk analysis process as possible, and should continue throughout the risk management process (North, 1995**)**. Risk communication fulfils several functions those are: exchanging scientific or factual information between all people involved with or interested in the risk issue; providing information about the risk perceptions and the level of risk acceptable to the different stakeholders; disseminating information about the acceptability and feasibility of various possible risk mitigation measures; disseminating information about the effects of proposed decisions and measures to allow for evaluation; encouraging and establishing trust between all those people and organizations affected by or interested in the risk issue(FAO, 2011).

2.2. Transboundary animal diseases

Transboundary animal diseases (TADs) have been described as "those diseases that are of significant economic, trade and/or food security importance for a considerable number of countries; which can easily spread to other countries and reach epidemic proportions; and where control/management, including exclusion, requires cooperation between several countries" (FAO, 1996). These mainly fall within the former list A of diseases of the Office International des Epizooties (OIE). They include a number of virus diseases such as rinderpest, peste des petits ruminants (PPR), foot and mouth disease (FMD), rift valley fever (RVF) and lumpy skin disease (LSD) as well as bacterial diseases such as contagious bovine pleuropneumonia (CBPP).

As described by Rossiter and Hammadi (2009) common features of TADs are the severity of losses that these diseases can cause; the speed and distance with which they can be transmitted in livestock or livestock products being transported by road, air and water; their susceptibility to control through effective vaccines and movement restrictions; the array of diagnostic tests that can accurately diagnose infection before transport; and the significant levels of scientific understanding of the natural history of these diseases.

2.2.1. Epidemiologic features of prioritized transboundary animal diseases

Common transboundary cattle diseases in Ethiopia include foot and mouth disease (FMD), lumpy skins disease (LSD) and contagious bovine pleuropneumonia (CBPP).

Foot and mouth disease

Foot and mouth disease (FMD) is the most contagious transboundary animal disease (TAD) affecting cloven hoofed animals. Significant economic losses are produced by its high morbidity and the export trade restrictions imposed on affected countries. There are seven recognised serotypes of FMD (O, A, C, Asia 1, SAT 1, SAT 2 and SAT 3), which differ in distribution across the world. Serotypes A and O have the widest distribution, occurring in Africa, Asia and South America. Types SAT 1, 2 and 3 are currently restricted to Africa only and Asia 1 to Asia; the capacity to invade free areas is common to all types and periodically SATs are introduced into the Near East, and Asia-1 into western and eastern parts of Eurasia (FAO, 2002; FAO, 2007). Endemic distributions of five of seven serotypes of FMDV are maintained in Ethiopia: serotype O, serotype A, serotype C, serotype SAT 2, and serotype

SAT 1. Infection or vaccination against one serotype does not provide protection against the other serotypes (Rufael *et al.*, 2008; FAO, 2007; Ayelet *et al.*, 2009, Negusssie *et al.*, 2010)

FMD is transmitted by a variety of methods between herds, countries and continents but spread from one animal to another is by inhalation or by ingestion. In endemic areas, the most important method of spread is probably by direct contact between animals moving across state and national boundaries as trade or nomadic cattle. The routes of spread include inhalation of aerosolized virus, ingestion of contaminated feed, and entry of the virus through skin abrasions or mucous membranes (Aftosa, 2007). The virus can persist in aerosol form for long periods in temperate or subtropical climates but not in hot and dry climates. The speed and direction of the wind are important factors in determining the rate of airborne spread. Humidity is also important but rain as such appears not to be. In the most favorable circumstances, it is now estimated that sufficient virus to initiate an infection can be wind borne as far as 250 km (156 miles). In cattle, the first site of virus infection and subsequent rapid multiplication is the pharynx. Following a few days of viremia, the virus appears in milk and saliva for up to 24 h before vesicles appear in the mouth. All other excretions including urine, feces and semen may be similarly infective before the animal is clinically ill and for a short period after sign have disappeared. Humans are often a vehicle for transmission of the virus. It has been recovered from the nasal mucosa of persons working with infected cattle for up to 28 h after contact (Radostits *et al*., 2006).

Lumpy skin disease

Lumpy skin disease (LSD) is caused by lumpy skin disease virus (LSDV), a DNA virus of the family Poxviridea and of the genus Capripoxvirus. The World Organization for Animal Health (OIE) categorizes LSD as a notifiable disease because of the substantial production losses and restrictions to the global trade of live animals and animal products.

LSD has been endemic in Africa for more than 70 years occurring in a wide range of ecotypes. The first outbreak in Egypt was reported in 1988 (Ali *et al*., 1990) but the disease has never reached northern African countries. Outside the African continent Israel has reported two outbreaks, the first in 1989 which was eliminated by the slaughter of all infected and contact animals (Yeruham *et al*., 1994), and the other more recently in 2006 (Brenner *et al*.,2006). LSD outbreaks have been reported in the Middle Eastern region since 1990 (Tuppurainen and Oura, 2012). The disease was first observed in the western part of Ethiopia (southwest of Lake Tana) in 1983. It has now spread to almost all the regions and agro ecological zones (Gari *et al*., 2010).

It is well accepted that lumpy skin disease is mechanically transmitted by different types of biting and blood feeding arthropods, although the importance of the vectors in the transmission of the virus in field conditions is not fully understood. *Aedes aegypti* was found to successfully transmit the virus between cattle up to 6 days after feeding upon infected animals (Chihota *et al*., 2001). Experimentally, stable flies (*Stomoxys sp*.) are able to mechanically transmit *capripoxvirus* between sheep (Mellor *et al*., 1986), and live LSDV has been isolated from stable flies after feeding on infected cattle (Weiss, 1968).

Direct contact could be a minor source of infection. LSDV occurs in cutaneous lesions, saliva, respiratory secretions, milk and semen. Shedding in semen may be prolonged; viral DNA has been found in the semen of some bulls for at least 5 months after infection. Animals can be infected experimentally by inoculation with material from cutaneous nodules or blood, or by ingestion of feed and water contaminated with saliva. LSDV is very resistant to inactivation, surviving in desiccated crusts for up to 35 days, and can remain viable for long periods in the environment (Rovid, 2008a).

Contagious bovine pleuropneumonia

Contagious bovine pleuropneumonia (CBPP), which is caused by *Mycoplasma mycoides* subsp. *mycoides* small-colony type (SC), (*mmmsc)* is the major cattle-raising and trade in Africa and in other parts of the world. Contagious bovine pleuropneumonia is endemic in parts of Africa including Ethiopia. Sporadic outbreaks are also reported in the Middle East, and are probably caused by cattle imported from Africa. The situation in Asia is uncertain, but in the past, this disease was reported in many countries. Although CBPP reemerged in Europe in the 1980s and 1990s, it was eradicated and has not been reported since 1999. The Western hemi-sphere remained free of the disease during the recent outbreaks (Rovid, 2008b).

M. mycoides SC is mainly transmitted from animal to animal in aerosols. This organism also occurs in saliva, urine, fetal membranes and uterine discharges. Carrier animals, including subclinically infected cattle, can retain viable organisms in encapsulated lung lesions (sequestra) for up to two years. These animals may shed organ-isms, particularly when stressed (Rovid, 2008b). Cattle movements are responsible for the transmission of the CBPP from one herd, region or country to others. Close, repeated contact is generally thought to be necessary for transmission; however, *M. mycoides* SC might be spread over longer distances (50 to 200 meters) if the climatic conditions are favorable (Masiga *et al*., 1996).

2.2.2. Socio-economic impact of transboundary animal diseases

Epidemic diseases such as rinderpest, foot and mouth (FMD), lumpy skin disease (LSD), and contagious bovine pleuropneumonia (CBPP) threaten national livestock industries by direct effects. These include high levels of morbidity and mortality, control or eradication programme costs and restrictions to trade in livestock and livestock products. The occurrence of such diseases impacts both poor and richer livestock producers by marginalizing them from higher price livestock markets and restricting their capacity for value-added trade.

Direct effects of TADs on livestock productivity include reduced feed intake, changes in digestion and metabolism, increased morbidity and mortality and decreased rates of reproduction, weight gain, reduced draught power and manure and milk production. These have aggregate effects that limit economically important herd-management decisions regarding animal selection and optimal longevity.

Many TADs have mortality rate 50-90% in susceptible animals (Otte *et al*., 2004). In the wake of the rinderpest pandemic of 1887 was estimated to have killed about 90% of Ethiopian cattle and more than 10 million cattle on the continent as whole (Mack, 1970). The total value of output loss incurred by CBPP in twelve sub-Saharan Africa countries was estimated at 30.1 million euros, giving an average of 2.5 million euros per country. The value of output loss ranged from 0.5 million Euros for Ghana to 10.3 million Euros for Ethiopia (Tambi *et al.*, 2006). As indicated by Tuppurainen and Oura (2012) in intensive cattle farming units, direct and indirect production losses caused by LSD have been estimated to be as high as 45–65%.

Indirect losses are often less visible than the obvious effects of clinical disease but may be equally or more important in their overall economic impact. Disease control has costs including vaccine purchase, vaccine delivery, disease surveillance, laboratory diagnosis and testing, quarantine and movement management. Expensive antibiotic treatment may be required for CBPP control. In twelve sub-Saharan Africa an investment of 14.7 million Euros was incurred to control CBPP (Tambi *et al.*, 2006). Yemen spends about US$ 250 000 annually to control PPR in only 10% of the total rural areas of the country (Rossiter and Hammadi, 2009).

The trade implication of TADs can cause a greater economic impact than the direct production losses themselves. The more developed countries have the systems and resources to cope with TADs either by preventing them or by responding rapidly and effectively to outbreaks. As a result most developed countries have eradicated the major TADs affecting their livestock. Outbreaks can and do occur in these countries, however, with disastrous financial implications resulting from the trade sanctions imposed by the international community on the infected country. FMD outbreak in 2001 in UK, for example, is estimated directly and indirectly to have cost US$12 billion (Thompson *et al*., 2002). The Rift Valley fever ban is estimated to have cost Kenya US $32 million in lost exports to the Gulf and other negative domestic impacts on agriculture and other sectors such as transport and services (Rossiter and Hammadi, 2009). Movement restrictions and local quarantines mean the closure of livestock markets and reduced or no opportunities for sale of live animals and possibly meat and other products. In addition to the measurable economic impact on a national economy the inability to sell one steer or some sheep or goats can bring severe hardship to a pastoral family with no other income of sources of support (Steffen *et al.,* 1998; Holleman, 2002). A small, localized and swiftly eliminated outbreak of FMD in a European country may cause very limited direct losses but the barriers erected against trade usually last much longer and cause much higher losses (Jha, 2007). One Australian study of the possible outcome there of an outbreak of FMD concluded that the total loss of real GDP could be as high as $US 7.1 billion over a 15 year period. This was based upon the assumption that FMD-free markets would be closed to Australia for a period of six years, leading to lower prices and increased slaughter of uneconomic livestock (Dent, 2002). The outbreak of CBPP in Botswana in 1994 led to a closure of its access to the EU market, resulting in a 60% decline in beef and other export products (Townsend *et al.*, 1998). FMD is one of the major diseases in Ethiopia that hampering export of livestock and livestock products to the Middle East and African countries; the Egyptian trade ban of 2005/2006, in which Ethiopia lost more than US$14 million(Leforban, 2005).

Finally, Transboundary animal diseases have significant and measurable effects on human welfare in developing countries. Particularly in pastoral societies, livestock contribute directly or indirectly to food security and nutrition a source of protein, micronutrients, animal power and tradable assets. Animal disease control and livestock products have been shown to have considerable impacts on improving child nutrition among poor people, particularly in pastoralist communities, in which 75 percent or more of general and child nutrition is based on milk and livestock products (FAO, 2002**)**. The growth of international trade in agriculture produce buffer potential impacts of TADs on food availability, but there can be still major impacts on poorer communities do have access to substitute supplies. The foods security impact is the paramount concern of many national policy-makers in developing countries and provides one of the main arguments in favour of international assistance for control.

2.2.3. The status of prioritized transboundary diseases in Ethiopia

Ethiopia has three important TADs that affect international trade; these are foot and mouth disease (FMD), lumpy skin disease (LSD), and contagious bovine pleuropneumonia (CBPP).

Foot and mouth disease was first recorded in Ethiopia in 1957 when serotypes O and C were found (Martel, 1974; Martel and Gallon, 1975). Current records from the National Animal Health Diagnostic and Investigation Center and National Veterinary Institute of Ethiopia indicated that serotypes O, A, C, SAT1 and SAT2 were responsible for FMD outbreaks during 1974–2007 (Sahle *et al*., 2004; Gelaye *et al*., 2005; Ayelet *et al.,* 2008 and Legess, 2008; Ayelet *et al.*, 2009;).

The records of Ministry of Agriculture and Rural Development (MOARD) from 1997 to 2006 indicated that FMD outbreak occurred every where through out the country with the highest in central part particularly in North Showa 128 outbreaks reported during the indicated period of time (Ayelet et al., 2008).

Recent studies conducted in southern Ethiopia (Rufael *et al*., 2008; Megersa *et al.,* 2009; Bayissa *et al*., 2011; Mekonen *et al.*, 2011), Southwest Ethiopia (Gelaye *et al*., 2009), Northeast (Shiferaw *et al*., 2010), Northwest Ethiopia (Mazengia *et al*., 2010), Eastern Ethiopia (Mohamoud *et al.*, 2011) and different regions of the country (Ayelet *et al*., 2008; Ayelet *et al*., 2009; Negusssie *et al.*, 2010) (Table 1) revealed that FMD is posing a major threat to cattle in many parts of the country thereby causing considerable economic losses through morbidity, mortality and trade restriction.

Table 1: Seroprevalence of foot and mouth disease in Ethiopia

Study areas	**Seroprevalence (%)**	**Reference**
Borana pastoral system	21	Rufael *et al.*, 2007
Southern Ethiopia	9.5	Megersa *et al.*, 2008
Borena and Guji zone	24.6	Mekonen *et al.*, 2011
Borena zone	23	Bayissa *et al*., 2011
Bench Maji zone	12.1	Gelaye *et al.,* 2009
Andassa dairy farm	14.6	Mazengia *et al*., 2010
Jijiga zone	14.05	Mohamoud *et al.,* 2011
Different parts of country	10.5	Ayelet *et al*., 2008;
Different parts of country	44.2	Negusssie *et al.,* 2010
South Omo Zone	8.18	Molla *et al*., 2010

Lumpy skin diseases first observed in the western Ethiopia (South west of Lake Tana) in 1983 and the assumption was that it has been introduced from Sudan (Mebratu *et al*., 1984). It has now spread to almost all the regions and agroecological zones with a major epidemic outbreak of LSD occurred in 2000/2001 in the northern parts of the country in Amhara and West Oromia. Then it extended to the central and the southern parts of the country in 2003/2004 covering large parts of Oromia and SNNP regions. In 2006/ 2007 another extensive outbreak reappeared in Tigray, Amhara and Benishangul regions in the northern and north-western parts of the country (Gari *et al*., 2010). The occurrence of disease is mainly associated with wet season of the year (July to December) in which it related to increase population of biting-fly (Gari *et al*., 2008; Gari *et al*., 2010). Taking into account the countrywide distribution of the infection and the size and structure of the cattle population in Ethiopia it is likely that LSD is one of the most economically important livestock diseases in the country.

There is a suggestion that CBPP was introduced into East Africa from India by the army of field Marshal Napier when he invaded Ethiopia in 1867-1868 (Masiga *et al.*, 1996). A total of 583 outbreaks of CBPP were reported between 1995 and 2002 in Ethiopia in which highest outbreaks (187) were reported in 1998 (Tambi *et al*., 2006).

Recent studies conducted in Western Ethiopia (Regassa, 2001; Beyene, 1997), Northwest Ethiopia (Takele, 1998), Southern Ethiopia (Wondimu, 1996), Eastern Ethiopia (Mekonnen, 2004) and different regions of the country (NAHRC, 2000) revealed that CBPP is posing a major threat to cattle in many parts of the country thereby causing considerable economic losses through morbidity and mortality and warranting for serious attention.

2.2.4. Control of transboundary animals diseases

Techniques and tools for the control of the major TADs already exist. They have been used so successfully in many countries that most have been eradicated from or prevented from infecting North America, much of Europe, much of Southern Africa, Australia and New Zealand. In these countries there is now nothing other than sporadic and localized outbreaks which are usually quickly dealt with (Bruckner *et al*., 2002; Pluimers *et al*., 2002). Improving disease reporting, surveillance, detection, preparedness and rapid response are key elements to tackle epidemics of FMD and others TADs worldwide.

Disease intelligence and active data search make use of information sources which go beyond those used for passive disease reporting systems. Such disease reporting and screening systems are developing and could be tapped to develop an animal disease early warning systems and the identification of emerging pathogens. In the developed countries continuing freedom from TADs is based on exclusion of the infections supported by early warning and early response.

The core requirement for enhancing the effectiveness of control activities against high-impact diseases is to develop risk-based surveillance systems that focus on the greatest payoff in detecting disease and demonstrating freedom from specific diseases. The chapter on the evaluation of Veterinary Services in the OIE *Terrestrial Animal Health Code* (OIE, 2004a) states that: ‘The Veterinary Services shall have at their disposal effective systems for animal disease surveillance and for notification of disease problems wherever they occur, in accordance with the provisions of the *Terrestrial Code.* The system will include “scanning” elements, which provide a broad assessment of the disease status of the country, and “focused” elements, which answer specific questions about national disease status. It will be risk-based, in that it will direct surveillance resources at activities and areas of the country in a way that is weighted according to the probability of adverse events and the likely consequences of such events (FAO, 2002).

Early detection and confirmation of suspect cases of disease is essential to ensure proper control and containment. In recent years, new and improved epidemiological methods have been developed to deliver disease surveillance. These include structured clinical and observational surveys of the population, serosurveillance, use of geographical information systems and remote sensing to provide information at lower cost than field data gathering, application of low cost strain-differentiation methods using molecular epidemiological techniques delivered through kits to eliminate high processing costs and interview methods to gather information direct from livestock herders. However, major losses to disease-control effectiveness in recent years have been the decline through under-resourcing of veterinary diagnostic services and the slow development of alternative ways of providing reliable diagnostic capability. This situation can have serious effects on the speed and effectiveness of the national response to an emerging disease threat.

The Manual on the Preparation of National Animal Disease Emergency Preparedness Plans of the Food and Agriculture Organization of the United Nations (FAO) (Geering *et al*., 1999), stipulates that each country should, as part of its early warning system, carry out risk analyses to determine the likelihood of exotic diseases being introduced. The risk of disease or pathogen introduction should be analyzed in relation to the country's geographical location and the disease situations of neighboring countries or trading partners. However, the state of current preparedness is inadequate, everywhere. For at least 20 years it has been obvious that the modern agricultural industries of the developed world cannot use 18^{th} Century methods to control naturally or intentionally occurring outbreaks like FMD in 21^{st} Century agribusiness without catastrophic damage and enormous economic costs. To try to do so is a grave mistake and there are much better alternatives. Government policymakers need to understand that control of inadvertent or deliberate FMD or other transboundary livestock diseases is not an animal health policy issue that can be left to agricultural authorities (Breeze, 2006).

The challenge of TADs control in endemic settings will require active partnerships to overcome the limitations of insufficient epidemiological information from these regions on the basis of which to develop targeted measures, and limited capacity and national resources to apply control measures based on mass vaccination or effective movement control.

Current vaccines commercially available against infectious diseases are of two categories. These are inactivated vaccines formulated with adjuvant and attenuated live vaccines. Although there is still scope for developing new vaccines and treatments for various diseases, the shortfall of greatest significance to poor livestock farmers is in low-cost, easy-to-use delivery systems. There is a need to move from current disease control through routine mass vaccination towards more subtle approaches in which management changes, targeted vaccination and other techniques are combined in integrated low-cost strategies. Such control programmes can make effective disease control a realistic possibility in poor communities by bringing the costs within reach. The potential for this is greatly increased if the immune response to the vaccine is such that it is still possible to differentiate infected animals from vaccinated but uninfected ones. Vaccines with accompanying discriminating tests are becoming more readily available and seem likely to be an important tool in the future. Local strain variation in disease agents needs to be considered. Although it is much more cost-effective to use generic vaccines that can be used for different populations, this must not be allowed to override the need to ensure that each vaccine genuinely provides protection in the various populations, otherwise the confidence of low-income communities in vaccination will be undermined (FAO, 2002).

For developing countries, disease eradication is even less feasible and has provided few benefits with regard to international trade. Even though rinderpest eradication has been achieved in most developing countries, the persistence of other TADs effectively limits trade opportunities. Crucially, unless a country can convince the international community and its trading partners that it is free in its entirety from most, if not all, trade-sensitive TADs/List A diseases, export of livestock commodities is difficult and often impossible. In developing countries, comprehensive disease eradication schemes covering more than rinderpest have rarely been implemented, for a variety of resource, technical and operational constraints. Developing countries, especially those in sub- Saharan Africa, are poor and tend to rely heavily on donor support for animal disease control programmes. Although these programmes may demonstrate impact during their lifetime, the resources that are required to maintain the benefits of aid programmes are often beyond the capacities of these countries (Thomson *et al*., 2004).

A possible alternative to national-level TAD eradication is eradication on a zonal basis. Indeed, the OIE recognises the potential to eliminate specific TADs from a zone or zones within an otherwise infected country. The approximately 170 OIE member countries can apply to the OIE for official recognition of freedom from four specific diseases (FMD, rinderpest, CBPP and BSE) on either a national or zonal basis. For other TADs, the Code recommends measures to achieve acceptable levels of risk when imports are considered, and accepts that complete freedom from risk, that is, risk-free trade, is unattainable. However, approaches to the eradication of TADs other than the four mentioned above and provisions for assessment by the OIE are not available.

To address transboundary diseases, many developing countries have strategies and policies aimed at establishing so-called ‘disease-free zones’ from which all TADs affecting trade will be eradicated. The designation of disease-free zones as part of a package of measures to enhance access to regional markets has been advocated. The Disease-free zones require the maintenance of fenced zones or compartments in which livestock are free of specified animal diseases. These are being promoted in Kenya and Tanzania in an effort to modernize pastoral production and enable livestock exports. However, the requirements for free zones applicable to more than one disease are not covered by the Code because ‘free zones’ as defined in the Code are disease-specific. Many countries (particularly in Africa) have to deal with a range of TADs simultaneously and therefore technical considerations can be extremely complex. The question arises, therefore, as to whether these problems could be addressed more effectively by an alternative approach (Thomson *et al*., 2004; Anon, 2009).

2.3. Structure and performance of Ethiopian live cattle market chain for export

The diverse agro-climatic conditions of Ethiopia make it very suitable for the production of different kinds of livestock. Most of the livestock are produced by pastoralists, agro-pastoralists, and smallholder mixed crop–livestock farmers and sold to private entrepreneurs operating in a value chain involving collection, fattening and transportation up to terminal markets. As a result the livestock market is structured in such a way that the marketable livestock from the major producing areas reaches to the final consumer or end-user passing through complex channels along the supply chains involving various actors including producers, middlemen, livestock trading cooperatives, traders, live animal exporters.

2.3.1. Supply chains for live cattle export

A supply chain is the series of interlinking steps that determine the nature, character and value of a product at the time of receipt by the consumer. Basically, a value chain describes the range of activities from the producer to the consumer. In its analysis, it is broken into networks of activities controlled by categories of functionaries and distinguishes the stages in the supply process and support services to accomplish the tasks. Various dimensions are analyzed in the chain which is very important in effective tracing of product flows, showing the value adding stages, identifying key actors and the relationships with other actors in the chain (Hubert, 2005). The out put in the chain are determined by the requirements of the market agents including, consistency, cost, variety, value added and innovation, food safety, ethical trade; which are, in turn, responding to demands of their customer (Dolan and Humphrey, 2000).

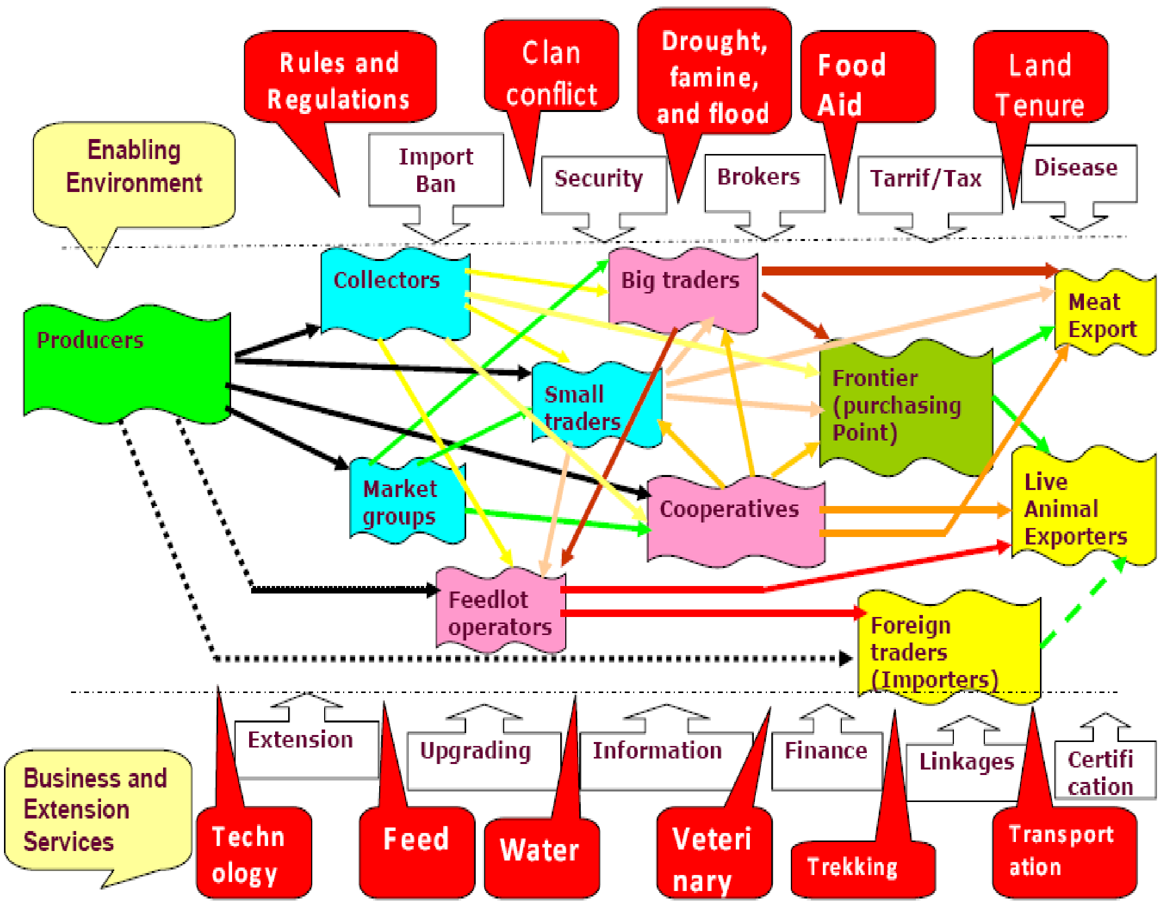
In Ethiopia, the export live cattle marketing chain actors are those who transact cattle as they moves along the chain from the primary producers to the end users: producers, middlemen, traders, feedlot operators' live animal exporters. The enabling factors for cattle export market business environment are the critical factors and trends that are shaping the market chain environment and operating conditions which are generated by structures and institutions (policies and regulations) that are beyond the direct control of the market participants. Inputs and other services from other enterprises or service provider organizations are provided for all the participants in the chain which will allow the actors to grow and maintain their competitiveness in the supply chain (Teklewold *et al*., 2009).

Conventionally, many livestock markets in Ethiopia are categorized into primary market, secondary market and terminal market (Legese *et al*, 2008). Marketing of live animals and meat generally starts with collection of livestock from production areas and village markets and moving on to terminal market in cities. In such marketing chains the livestock passes successively through a number of market actors, implying the links in value chains before it reaches to end users (Teklewold *et al*., 2009).

Although the majority of Ethiopia's livestock is found in the highlands, 95 percent of the livestock intended for export is supplied by the pastoral and agro-pastoral areas of Afar, Somali and Borena. A large percentage of the cattle exported from Ethiopia originate in Borena, and this area stages a fierce purchasing competition between live animal and meat exporters. Borena Zone is known for its high population of cattle (Farmer, 2010).

The live cattle marketing channels for cattle found to be different from those of shoat in that additional type of market participates such as feedlot operators were involved in some channels of the traded cattle (Fig.3).

Recently, Middle Eastern countries such as kingdom of Saudi Arabia, United Arab Emirate, Kuwait, Yemen, Bahrain, Jordan and Egypt are the primarily targets of Ethiopian live cattle export. There are multiple channels for livestock from Ethiopia. Only 20% of the livestock trade in Ethiopia passes through formal channels, compared with the estimated 80% of export trade that passes through unofficial, informal channels (Anon, 2009). Informal or illicit cross-border trade accounts for the majority of live animal exports from Ethiopia, as it tends to be simpler and less expensive for exporters. In 2006/7, the volume of informal exports was estimated at 328,000 head of cattle (Aklilu, 2008). Formally, Ethiopia exports approximately 200,000 livestock annually. Of the 200,000 live cattle exported formally, approximately 40,000 are exported from Amhara to Sudan, while smaller volumes of cattle are exported formally to Somalia and Kenya. The majority, however, is exported through Djibouti (Farmer, 2010).



Source: Legese *et al.*, 2008

Figure 3: Generalized live animals and meat export market chain

2.3.2. Market participants

The livestock marketing system in Ethiopia is very complex, linking a number of different types of market actors as the marketed animals move from producers to the processors or end users. The different links in the process of market chain indicate the different service that are provided the deliver the livestock or meat to various consumers. In the livestock- marketing channel serving the export market, different type of operators with different socio-economic characteristics are usually participated. These involve traders, collectors, cooperatives, purchasing agents, brokers, and live animal exporters. These market actors play limited participation on value addition process in existing various marketing chain except few market services such as transporting and limited fattening operation (Teklewold *et al*., 2009). Exporters are few in number compared to traders in the market. However, the number of these actors in the live animal export sector is increasing from time to time. Foreign exporters-importers are increasingly purchasing animals from within Ethiopia, using Ethiopian traders as collecting agents in primary and secondary markets (Legese *et al.*, 2008). This is driving a different kind of vertical integration within the value chain, which increases efficiency but also foreign influence within the Ethiopian livestock trade.

Most of the feedlot operators are available at Adama/Nazareth and Dera areas with their main role of fattening cattle for different markets. As part of SPS requirements and according to the rules and regulations of animal quarantine, fattening is operated after providing the cattle with necessary vaccines and medication. The feedlot operators are collecting cattle either from Dera and Adama/Nazareth markets or from the main source markets. They use Borena markets as the main source market because of accessible transportation, and their preference for cattle sourced from these areas due to fast growing, large body size, efficiency in feed conversion and adaptation to harsh environments. Feedlot owners show a strong preference for Borena cattle due to its large size, efficient feed conversion and superior meat quality (Legese *et al.*, 2008).

2.3.3. Seasonality of livestock flow

The livestock markets in most parts of the country are characterized by seasonality in low and prices of animals. In pastoral areas, the supply of livestock is highly seasonal and only somewhat related to market demand. Other determinants of supply fluctuation include water and pasture availability (particularly dry season vs. wet season), disease outbreaks and availability of food aid (which helps relieve pressure to sell animals for cash or grain purchases), clan conflicts and others.

Livestock prices have shown a seasonal pattern where prices are at peak during rainy season (June to September) and drops in the other months. This is basically because of low supply of animals to the market during rainy season as farmers are usually engaged in other farming activities at the time. Availability of good grazing pasture is also another factor contributing to low supply of animals during rainy seasons (Legese *et al.*, 2008). Gezahegne *et al.* (2006) also indicated that input constraints like feed and water shortage could significantly affect the supply and sales of animals.

Seasonality in prices is also driven by seasonality in demand. Gezahegne *et al.* (2006) noted that prices depend mainly on supply and demand, which is heavily influenced by the season of the year and the occurrence of religious and cultural festivals on the one hand, and occurrence of drought or other weather shocks on the other.

2.3.4. Livestock feed

Escalating feed costs, in view of rising fuel and grain prices, remain major impediments to value adding for livestock. In Ethiopia, the average cost of feed has risen from Birr 8 to Birr 20/day (USD $0.93–2.08) per head in the feedlots and transport. A study on livestock feed also shows that 80% of the traditional feed provided to cattle at the smallholder level is used for body maintenance only (Akililu, 2008).

Natural pasture is the main source of feed for most of Ethiopia’s livestock, complemented by fodder and crop residues during the dry season. Of the various crop residues used as livestock feedstuffs, teff straw is the most commonly used for fattening. Agro-industrial by-products and commercial feed mixes are less commonly used by small-scale livestock producers, although they are critical inputs for livestock fattening prior to slaughter or export. In particular, wheat bran from flour mills and oilseed cakes from edible oil factories are an important source of feed ingredients. Among seed cakes, linseed and cotton seed cake are generally used for fattening, while noug is used more often for dairy. There are approximately five commercial feed mixers and millers in Ethiopia, located in Adama, Modjo, Debre Zeit and the industrial areas of Addis Ababa (Akaki and Kality). Approximately 10 additional mixer/millers produce feed primarily for their own use (Farmer, 2010).

2.3.5. Bottleneck in cattle market chain

Ethiopia ranks first in livestock resources in Africa with the potential to export substantial numbers of live animals. However, various constraints continue to hinder international trade to destinations of choice turning the country into a major supplier of live cattle. Despite substantial demand, the livestock system currently struggles to supply quality cattle and generate income from beef marketing. Production is highly fragmented and geographically dispersed, and is not market oriented resulting in lack of a constant and uniform supply of marketable animals. Offtake in Ethiopia is low compared with that in other East African countries, suggesting that many livestock holders prefer to keep their live cattle for domestic use rather than sell them (GebreMariam *et al*., 2010). Furthermore, Ethiopian cattle market value chain is constrained by: i) lack of an efficient and effective livestock marketing system which is characterized by limited market information, absence of a livestock grading system to provide incentives to producers and limited promotion, ii) limited knowledge by and capacity of value chain actors (producers, dealers, transporters, meat handlers, etc.) to meet international market standards, iii) poor market infrastructure and lack of proper transport services, iv) prevalence of livestock diseases and inadequate veterinary support services. There have been frequent export bans mainly due to the stringent health requirements of some importing countries, v) poor feed supply and low feed quality and vi) demand for draught power for agro-pastoral systems competes with live bulls sales for young males, leading to predominant sales of aged, low-quality cattle (Teklewold *et al*., 2009; GebreMariam *et al.*, 2010).

Another important constraint affecting cattle market chain actors is limited access to market information at the grassroots level. Pastoralists and traders lack clear and detailed knowledge on the desired livestock characteristics and health requirements of importing countries. Further, these producers are also not adequately informed of the importance of establishing source of origin, traceability mechanisms, and related certification processes for marketed animals. Chain actors do not yet appreciate the importance of issues related to food quality, the link between animal health, meat quality and safety, and why documentation is fundamental in enhancing competitiveness in the global market.

2.4. Participatory appraisal

Livestock sectors are constantly evolving in order to meet the changing needs of globalized society. This process can bring new and changing disease risks. Networks and linkages in value chains that link production systems, markets and consumers constitute a contact network, which provides opportunities for the transmission of contagious diseases within and between sectors. It follows that these chains (networks) must be understood and taken into account in planning risk management strategies for disease prevention and control.

Value chain analysis is essential to an understanding of markets, their relationships, the participation of different actors, and the critical constraints that limit the growth of livestock production and consequently the competitiveness of smallholder farmers. These farmers currently receive only a small fraction of the ultimate value of their output, even if, in theory, risk and rewards should be shared down the chain (Rota and Sperandini, 2010).

Risk-based management of animal disease should be people-centered. This means identifying the people involved (stakeholders) in the livestock sector and examining how they operate, how they perceive risk and what determines their risk profiles. It also means determining their resource bases, the profitability of their business and their alternative opportunities, as well as their constraints in terms of regulations, investment in human capital and infrastructure.

In this regard, the use of participatory approaches and methods to improve our understanding of the patterns of diseases in value chain is crucial. These approaches and methods are derived from participatory rural appraisal (Ameri *et al*., 2009). The techniques of participatory rural appraisal (PRA) are used to formulate the programme objectives, gather epidemiological data and intelligence, and analyze information (Jost *et al*., 2007). Participatory epidemiology (PE) is based on conventional epidemiological concepts but uses participatory methods (Chambers, 1983; McCracken *et al*., 1988). Participatory methods were first used to approach epidemiological questions in small-scale, community based projects, where technical assistants had close contact with livestock-keepers, and needed practical methods of assessing targeted animal health activities within realistic time frames (Jost *et al*., 2007).

The PE approach was developed to overcome the constraints in applying conventional epidemiology and formal research in developing countries. Conventional epidemiology can be expensive and logistically complex, producing large quantities of information from formal surveys that are often biased, spatially, behaviourally and logistically. Furthermore, as researchers generally do not understand the local context, quantitative information is often misinterpreted (Chambers, 1983)

Participatory risk analysis should be used together with value chain analysis in order to identify risk hotspots in the value chains. In livestock value chains there are many stakeholders who may affect and be affected by disease hazards in different ways; these people may face different levels of risk and may be affected by prevention and control measures in different ways. Participatory risk analysis can also provide information about the feasibility of the control measures and their potential impact on the people involved in the value chain.

2.4.1. Participatory appraisal tools

Participatory rural appraisal is an effective qualitative tool for researchers to collect data at the community level and places more emphasis on the empowerment of the community to process and utilize the information on their own. This information can be used to design better animal health projects and delivery systems, more successful, timely and sensitive surveillance and control strategies or as new perspectives for innovative research hypothesis in ecological epidemiology (Schwabe, 1984). Participatory approaches are based on open communication and transfer of knowledge, using a toolkit of methods guided by some key concepts and attitudes. The methods include: semi-structured interviewing, focus-group discussions, ranking and scoring disease observations, a variety of visualization (e.g mapping and modeling) and diagramming techniques (e.g. seasonal calendars and historical timelines) (Jost *et al.*, 2007).

To have a more complete picture, all the points of view must be cross checked or "triangulated". In practice, triangulation implies combining and contrasting data from various viewpoints. It is common to find that actors describe issues that, under revision, turn out to refer to aspects of the same problem (Lundy *et al*., 2007). When investigating subjects such as livestock disease, local experts can be identified who are respected by their communities for possessing specialist knowledge (Catley, 1997). Several types of field data form the core of PA study that includes spatial, temporal, social, and technical data can be collected.

The semi-structured interview (SSI) has some relation with veterinary medicine in history taking and subsequent tentative diagnosis. The SSIs prompts one to have a checklist of some questions, followed by the follow-up questions for the informants for further information (Catley, 1999; Catley and Mohammed; 1996). For the visualization methods, mapping-involving construction of a map on the ground using locally available materials has been used in animal health surveys (Catley, 1999). For spatial data, maps and transects are used (Lelo *et al.*, 1995). For temporal data, the tools that have been employed are timelines, trend lines, and seasonal calendars. Ranking and scoring methods have been widely used whereby informants are required to compare items or problems in pairs and decide the most important; the results are presented in a matrix with a total rank calculated (Catley, 1999). This scoring method, made visual when a matrix is drawn on the ground, with items along X-axis and indicators along the Y-axis, and stones used to score, has been used in northern Somalia to understand associations between different types of ticks and health problems (Catley and Aden, 1996).

Another visually oriented scoring method is proportional piling (Catley, 1999). The method involves the use of a large pile of counters like stones. The counters are usually 100 that the informants are asked to distribute on different items to show the relative sizes or importance

Most of PA tools have been used to produce qualitative data and PA survey results are presented in a descriptive rather than numerical form. However, virtually any qualitative data can provide numerical data if transformation occurs at an early stage in data collection process, by defining the number of items to be scored and the number of stones to be used for the scoring of indicators. Specific indictors could be defined by the researchers and added to those produced by the informants. Replication of the standardized scoring tool would allow statistical analysis for non-parametric data.

3. MATERIALS AND METHODS

3.1. Study area

The study was conducted East Shewa Zones. East Shewa Zone is located in the central parts of Oromia regional state of Ethiopia. Absolute location of East Shewa Zone extends from 7^0 33’50”N to $9^0$08’56”N and $38^0$24’10”E to 40^0 05’ 34”E which indicate that this zone is located in tropical climatic zone though the climate is influenced by altitudinal variation. The total area of east Shewa Zone is approximately 9,633.52km^2. The altitude ranges from 500 to 4307meter above mean sea level. The Zone can be categorized under rift system of oromiya since about 93% of the total area of the zone is completely located in rift system. East Shewa Zone comprises 32 districts of which 67% are mid altitudes and 33% are lowlands. The mean annual temperature varies between 18^0c and 30^0c and its mean annual rainfall is 410mm-820mm. Natural vegetations grown in East Shewa Zone are grouped under the Acacia wood land and savannah vegetation. In the study area, Adama and surrounding areas hosts a total of 200 feedlots of various sizes. The feedlots are located in urban and peri-urban areas. The larger feedlots produce about 2,000 to 3,000 heads of cattle a year while the smaller ones hold about 10 to 20 heads at any one time (MoA, 2010).

3.2. Studied population and source of information

The studied population consisted of bulls at finishing phase for export in East Shewa zone. The origins of the bulls were mainly Borena pastoral system and very small proportion from Bale lowlands. All animals used for study were male with 3-5 years age category and vaccinated for FMD, CBPP, LSD and other three bacterial diseases.

For seroprevalence study of FMD and CBPP, 38187 serum samples collected for one year (2011) from apparently health bulls for certification purpose were used. For outbreak investigation of LSD, all bulls found in 20 export oriented feedlots in and around Adama willing to participate in the study were used to follow up the occurrences of new case of LSD between July and December 2011.

Participatory appraisal methods (Catley, 2005) such as semi-structure interview (SSI) pair-wise ranking and matrix scoring techniques were used to generate information from 10 informant groups with group size varied from 4-11 in 8 sites of feedlot operations. Data for the risk assessment parameters was obtained from secondary data, interview with 31 feedlot operators, and personal field observations and from scientific literatures. Check list were used to estimate level of biosecurity in all feedlots (Annex 4).

3.3. Methods of risk assessments

This study used the framework that has been recommended by the World Animal Health Organization (OIE, 2004a) for risk analysis. The framework outlines four key steps that should be covered systematically. These are release assessment (probability of release from the source); exposure assessment (probability of exposure to the hazard); consequence assessment (biological consequences such as prevalence and economic consequences, etc.) and Risk estimation (which consist of combining the release, exposure and consequence probabilities). The risk assessment was taking into account the national value chain of borena live cattle for export only due financial and time constraints. The basic framework used is shown in Figure 4.

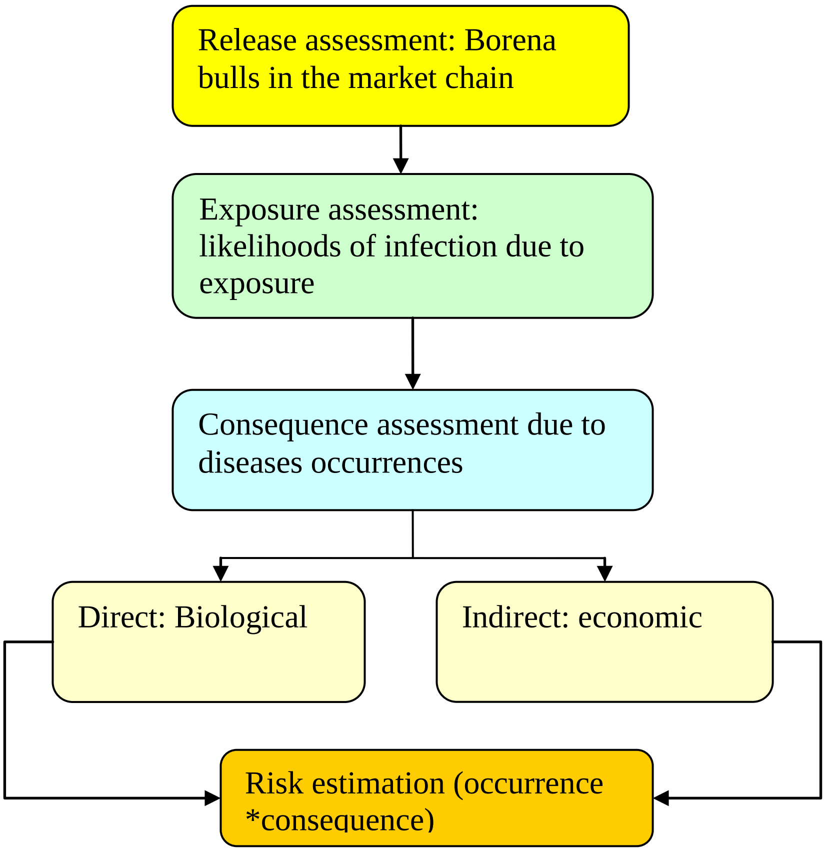


Figure 4: General scheme of the assessment (OIE method)

In this risk assessment, the hazards are defined as the FMD and LSD viruses and *Mycoplasma mycoides* subsp. *mycoides* small-colony type (*Mmm*SC) bacteria. The events that were considered as contributing to the release and exposure pathways were specified and broken down into several stages, with each stage being assigned a conditional probability. The overall probability of a given pathway was then arrived at by combining the probabilities of the various stages.

Qualitative risk assessments were conducted for release and exposure in which the probabilities were assessed and described textually. Quantitative data was used to assess the consequence. The categories of risk used in this study for the release and exposure ranged from negligible to very high (Table 2).

Table 2: Interpretation of probability categories

Probability Category	**Interpretation**
Negligible	Event is so rare that does not merit to be considered
Very low	Event is very rare but cannot be excluded
Low	Event is rare but does occur
Medium	Event occurs regularly
High	Event occurs very often
Very high	Event occurs almost at certainly

Adapted from EFSA (2006)

Each risk estimate is associated with some level of uncertainty. The lack of knowledge (uncertainty) regarding the mechanisms used to generate the probability estimate was classified according to both scientific information on literatures (Pfeiffer, 2007) and the information obtained during the epidemiological investigation in the studied area: (i) low (solid and complete data available); (ii) medium (some but not complete data available); and (iii) high (scarce or no data available). Uncertainties were demonstrated within brackets after likelihood estimates.

3.3.1. Release assessment of prioritized transboundary diseases

To assess the risk, the probability that each stage in the release risk pathways were occurred considered separately for the tree prioritized TADs. The overall probability of a release pathway was then arrived at by combining the probabilities of the various stages. Release risk pathways involved only national Borena live cattle value chain for export. Scenarios tree was designed to describe and evaluate the pathway of introduction of each prioritized TADs through traded bulls from the point of production until the feedlots in Central Ethiopia. Scenario trees contain nodes that describe the events from which probabilities of an event derive; these probabilities were qualified according to the aforementioned terms.

The risk question posed for release was "What is the probability of introduction of prioritized TADs agents into feedlots by Borena bull moving along market chain?" In this study, both scientific literatures and epidemiological information were used. Scientific literatures were used to obtain information on prevalence of FMD, LSD and CBPP in borena cattle, susceptibility of Borena bulls for those diseases and incubation period of the diseases. The presence of veterinary pre-purchase inspection and certification at markets, appropriate facilities required for pre-purchase inspection at market and disposal practice in the feedlots and feedlot operators' abilities to detect and exclude the hazard upon release were assessed by semi-structured interview (Annex 3) and personal observations. Annex 1 presented data required for the assessment of risk for release of prioritized TADs via traded cattle in the market chain.

3.3.2. Exposure assessment of prioritized transboundary diseases

The risk question for exposure was described as: "What is the probability that bulls in value chain become infected by TADs after the release of the agents by an infected traded bull passing along the market chain?"

The exposure pathway describes the direct and indirect transmission pathways by which the infected bull pass along the market chain transmit the diseases to bulls in the feedlots was designed. To assess the risk, the probability that each stage in the exposure pathways were occurred considered separately for the three diseases. Recent scientific evidence from literature and epidemiological information were used in each stage and the overall probability of exposure pathway was then arrived at by combining the probabilities of the various stages.

For the overall probability of FMD exposures, the assessment considered the probability of infection of bulls in the feedlots by FMDV from infected traded bull, probability that scavengers infected or contaminated with FMDV from carcasses of infected bull have effective contact with bulls in the feedlot and this contact leads to infection, probability that feedlots staff handling live and dead bulls get contaminated with FMDV and transmit to bulls in the feedlots.

The likelihood of LSD exposure assessment considered two pathways. These were probability of infection of bulls in a feedlot after exposure to LSDV from contaminated blood- feeding arthropods and probability of infection of bulls in a feedlot after exposure to LSDV from contaminated equipments. The likelihood of CBPP exposure assessment considered the probability of infection of bulls in the feedlots by *Mmm*SC from infected traded bull. Information required for the assessment of risk of exposure of prioritized TADs is presented in Annex 2.

3.3.3. Consequences assessments of prioritized transboundary diseases

The direct consequences because of disease occurrence such as mortality (biological) and indirect consequences such as embargoes (economic) were evaluated. The direct assessment was based on information collected from feedlots found in East Shewa Zone of Oromia Regional States by using serological and clinical investigation. Serological investigation results of FMD and CBPP conducted using 3ABC ELISA and C-ELISA and stored in Adama plant and animal quarantine center were used to determine annual seroprevalence, respectively. Cohort study was used to examine LSD cases at feedlots in and around Adama. Economical assessment was done by estimating economical loss encountered due to occurrences of diseases resulting in bulls mortality and rejection due to detected TADs.

Clinical and epidemiological investigation of LSD outbreak

In all participated cattle feedlots, cases of LSD diagnosed by feedlot's veterinarian and/ or bulls' attendant were clinically examined. In addition, bulls in all pens were observed by veterinarian and any suspects of LSD case were examined. Bulls with suspected case of LSD were examined for physical status, temperature, superficial lymph node and skin lesions according to Rodostits *et al*. (1995). Performance data collected were used to evaluate impact of LSD morbidity and mortality on cattle export (Annex 5). For each feedlot under investigation completed data entry forms were supplied and asked to record with regular monthly visits until the bulls were exported. All deaths in the participated feedlots were recorded during study period in order to know proportion of LSD death form total death in the study period.

Serum samples collection and processing

Serum samples collected for one year (2011) period for certification purpose from bulls between 3-5 years age were used for seropositivity determination. Blood samples were aseptically collected using 10 ml plain vacutainer tubes from apparently healthy bulls through jugular venipuncure. The tubes were then labeled with tag number of animals and kept protected from direct sun light in slant position until the blood clotted and sera were separated. The clotted blood or separated sera were transported to National Veterinary Institute (NVI) laboratory and National Animal Health Diagnostic and Investigation Centre (NAHDIC) for investigation. Serum samples were examined for antibodies to 3ABC non structural proteins of FMD virus using a commercially-available enzyme-linked immunosorbent assay (ELISA) test for identifying infected animals from non infected ones. Competitive Enzyme Linked Immuno-Sorbent Assay (C-ELISA) test were used to identify CBPP seropositive and seronegative animals. A total of 38187 bovine sera test results for both FMD and CBPP were used for this study.

Direct economical loss estimation

Economic losses caused by TADs were calculated based on mortality rate of LSD and rejection rate due to FMD, LSD and CBPP from international markets. Parameters used for economic estimation were the annual (2011) serum tested for FMD and CBPP and total animals at risk during the outbreak of LSD, average weight of the bulls, average market prices in terminal market for export, mortality rate of LSD and the rejection rates of bulls due to FMD, LSD and CBPP. Total numbers of animal at risk for LSD were obtained from Adama Plant and Animals Quarantine Center records. Total animals at risk of LSD during the outbreak were 18864 bulls.

3.3.4. Participatory assessment of perception of feedlots operators to the risks

Semi-structured interviews (SSI) (Annex III) were used to understand perception of feedlots operators to transboundary animal diseases (LSD, FMD and CBPP) risks. Interviews with local veterinarians provided *Aftegir/Maz* names for FMD, *Fentata/Gurebrebta* for LSD, and *Samba/Sal* for CBPP and other two cattle diseases (Patuerella (*Gororesa*) and Bloat

(*Hodemenefat/ Garaa-bokokusa*). Pair-wise ranking was used to establish the relative importance of the 5 priority diseases the perspective of the feedlot operators by explaining the local indicators (signs) for each of the diseases. This process was also used to generate indicators for matrix scoring.

Matrix scoring was used to score the five top ranking diseases against a list of clinical, epidemiological, production and market indicators. The matrix scoring was adapted from the methods described by Catley (2005). The five diseases identified above were presented using by either written names on cards or on the paper, or use local objects or pictures based on literacy of participants and placed along the tope X-axis of the matrix. Each of the five diseases in the matrix was scored against a list of 12 indicators/clinical signs. The indicators were illustrated along the Y-axis of the matrix. For each indicator, informants were asked to score each disease by dividing piles of 25 stones against the five diseases. After the Matrix scoring was standardized the procedure was repeated with other informants. The level of agreement between informant groups was assessed using the Kendal's coefficient of concordance (W) calculated using the Statistical Package for the Social Sciences (SPSS, 2007). Evidence of agreement between informant groups was categorized as 'weak', 'moderate' and 'strong' according to published guidelines on the interpretation of W (Siegel and Castellan,1994)) and the p-values assigned to W by SPSS software. Accordingly, agreement was termed weak for $W<0.26$, $P>0.05$; moderate for $W=0.26–0.38$, $P<0.05$ and strong for $W>0.38$, $P<0.01$.

3.3.5. Risk estimation of prioritized transboundary diseases

The risk estimate for the diseases occurrence in the market chain was made according to the combination matrix presented in Table 3. For example, if the probability of the introduction of a disease is moderate, and the probability of exposure high, then it will result in a moderate conditional probability of disease occurrence (i.e. moderate *high = moderate). The consequence estimation was base the biological and economical impact in the feedlots due to the prioritized transboundary diseases.

Table 3: Risk categories combination matrix

Parameter 1 / Release Risk Category	Parameter 2 /Exposure Risk Category				
	Very low	Low	Medium	High	Very high
Very low(VL)	VL	VL	VL	VL	VL
Low (L)	VL	L	L	L	L
Medium (M)	VL	L	M	M	M
High (H)	VL	L	M	H	H
Very high (VH)	VL	L	M	H	VH

Adapted from Zepeda (2007)

3.4. Data management and analysis

Data were classified, filtered, coded using Ms Excel 5, and was transferred to Statistical Package for Social Sciences software version 16 (SPSS software V.16).Thereafter analyzed according to the different variables. Pearson chi-square was used to evaluate the statistical significance of variables. Agreement among the scores of informant groups was assessed using Kendall coefficient of concordance (W) (Siegel and Castellan, 1994). In all the analyses, confidence level (CI) was at 95% and $P \leq 0.05$ was set for significance.

4. RESULTS

4.1. Risk assessment of foot and mouth disease

4.1.1. Release assessment of foot and mouth disease

The pathway in which FMD could be introduced to the feedlots through Borena bull in market chain is shown in Fig.5. According to SSI result 100% of feedlot operators preferred young Borana bulls (three to four years old) for fattening to export. Furthermore, survey indicated that 80.6% feedlot operators use Borena markets as the main source of bulls and 19.4% feedlots operators used Dera and Adama markets for purchasing Borana bulls for their feedlots.

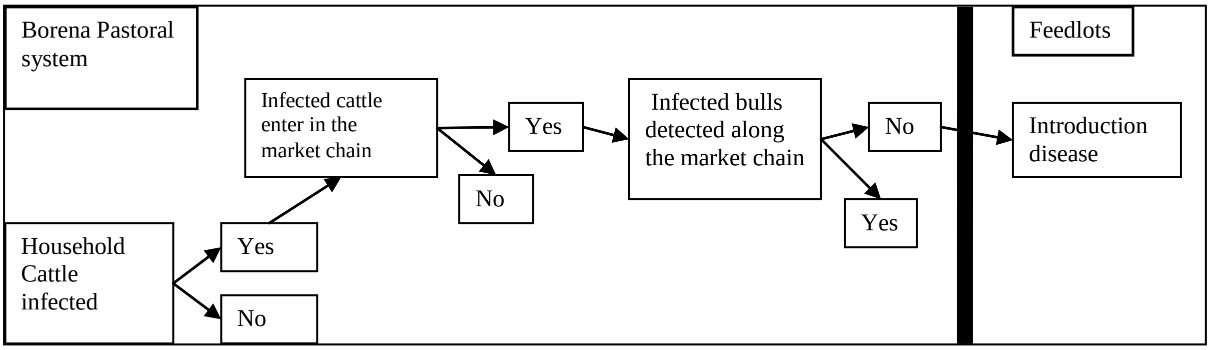


Figure 5: Scenario tree outlining disease pathway along the chain

Probability of Borena cattle in the market chain infected with FMD

Different studies in Borena Zone indicated that FMD was endemic in Borena pastoral system. FMD was reported as one of the main diseases of Borana cattle more than 15 years ago (Coppock, 1994), indicating the long-term presence of the disease compared to other cattle diseases. Borena cattle population has 55.2% to 58.6% herds which have at least one FMD infected cattle (Rufael *et al*., 2008; Bayissa *et al*., 2011). Mekonen *et al.* (2011) also indicated in their study that 53.6 % of FMD infected cattle are found in Borena Zone. Borena bulls are susceptible for all circulating serotypes of FMDV in Ethiopia (Ayelet *et al*., 2009).

As national plan for progressive control of the disease on a short, medium and long-term basis, FMD surveillance program was carried out in Borena pastoral system by Yabello Veterinary Laboratory in cooperation with Sebeta National Animal Health Diagnostic and

Investigation Center (MoA, 2010). However, due to shortage of equipments and kits, inadequate budget and logistic problems, the laboratory works with lower capacity to investigate outbreaks timely and to carry out regular surveillance activities. Currently, there is no government strategy in FMD control through vaccination and movement control (Bayissa and Bereda, 2009). Lack of vaccination strategies (quality, coverage and timing) and uncontrolled animal movement are thus the main factors that could increase the outbreaks of FMD in endemic areas such as Borena Zone (FAO, 2007). This fact indicated that FMDV is spreading in the Borena pastoral area within and between the herds without any control intervention.

Number of bulls purchased per markets varied to a great extent based on markets. The bulls were transported using small trucks. The bulls can get infected at market, collection site and during transportation, increasing the probability of a bull reaching the feedlots in Central Ethiopia shedding the virus. Taking into consideration the prevalence of FMD in Borena zone and susceptibility of Borena cattle, the probability that an infected bull entered to the market chain is therefore high (low uncertainty).

Probability of FMD infected Borena bulls not detected along the market chain

Clinical signs of FMD usually develop in 3 to 5 days (Kitching, 2002), although in natural infection, the incubation period may range from 2-14 days. Recovered or vaccinated cattle exposed to diseased animals can be healthy carriers for 6-24 months (Aftosa, 2007). According to SSI result average time spent on transportation from production areas to feedlots in central Ethiopia was 1.65 days. Since cattle from production area to the feedlots spend less than 2 days, the likelihood of an infected animal without clinical sign undetected along the market chain is high. Markets survey further indicated that at various points in market chain from primary market to feedlots in Central Ethiopia, there was no veterinarian performing pre-purchase inspection and selection for quality assurance and certification for live cattle. The traded animals were not subjected to any tests before they were moved into feedlots. Pre-purchase inspections along the market chain have been conducted by traders or purchaser groups without necessary animal health knowledge. The SSI result also indicated that 87.1% of feedlots operators have trend of buying animals as batch. This buying system could increase the probability of an infected bull with unapparent infection to pass undetected along the market chain. Sensitivity for clinical inspections of FMD during the early stages is low (sens: <0.1) (Achterbosch and Döpfer, 2005). The probability of not detecting the infected Borena bull under the specified conditions is therefore assessed to be very high (low uncertainty).

Probability of lack of containment of the FMD virus

Markets survey revealed that pre-purchase inspection by purchasers group involves a visual and physical evaluation of animal while moving freely in the market with low possibility of examining the bulls thoroughly. According to personal observation, purchasers open the oral cavity of the bulls with their hands to determine the age using teeth eruption. This trend could be a source of infection for the traded bulls in the market from hands contaminated with the saliva of infected cattle. In 93.5% of observed feedlots, carcasses were disposed nearby feedlots where scavengers and insects have easy accesses with high probability of contaminating the environment. According to our observation, 83.9% of feedlots have isolation pens, however, 76% of pens were found adjacent to pens where healthy bulls were kept with possibility of viral transmission from infected bulls to healthy bulls by means of aerosols (Kitching, 1992). In 100% of surveyed feedlots, staffs do not use any protective cloths while handling bulls and also do not use sanitary and disinfection facilities to avoid contamination. Generally, there could be an introduction of unobservable FMD infection via traded bulls; contaminated scavengers and contaminated staff. The facility along the chain would not help to identify and exclude the risk from introduction of the virus to the feedlots. Thus, due to lack of biocontainment of the virus along the market chain, the probability of introduction of the virus into the feedlots is considered to be high (low uncertainty).

Summary of release assessment for FMD

The finding of this assessment suggests that the overall risk for the release of FMDV in feedlots is estimated to be high with low uncertainty (Table 4). Release pathways probabilities vary from high to very high. Therefore, the probability of FMDV release to value chain by traded bulls occurs very often (Table 2).

Table 4: Summery of release assessment for FMD

Risk pathway	Risk Category	Uncertainty
Probability of Borena cattle in the market chain is infected with FMD	High	Low
Probability of infected Borena bulls is not detected while passing along the market chain	Very high	low
Probability of lack of biocontainment of the virus within the facility along the value chain	High	Low
Overall risk estimate for release	High	Low

4.1.2. Exposure assessment of foot and mouth disease

Assuming that FMD has been introduced into the value chain through infected bull from Borena pastoral area, other bulls in the feedlots could get infected directly or indirectly. The pathways through which bulls in the feedlots are exposed to FMDV are presented in Fig. 6.

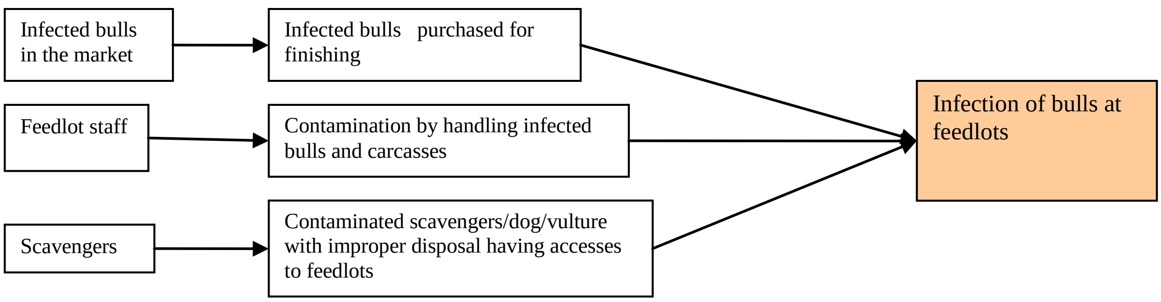


Figure 6: FMD exposure pathway

Exposure pathway1: exposure of bulls from infected bull

According to SSI results, the bulls are usually introduced into feedlots without quarantine. The transmission of the disease through contact between newly introduced and previously purchased bulls is highly likely as bulls are free to move in the barn (Fig. 7) and share common feed and water which may be contaminated by the excretions and secretions of a bull infected or found in incubation period. Although, 83.9 % of feedlots have isolation pens for sick animals, 76% of pens were found adjacent to pens where healthy bulls were kept with possibility of viral transmission from infected bulls to healthy bulls by means of aerosols (Kitching, 1992). Vaccination of bulls started after two weeks of registration by Adama veterinary controlling authority. The length of time from introduction of first batch of bulls to vaccination is sufficient to transmit the disease to healthy bulls. The aerosolised virus is resistant to external influences including common disinfectants. It may persist for over 1 year in contaminated premises. The virus also can persist in aerosol form for long periods in temperate or subtropical climates. In the most favorable circumstances, it is estimated that sufficient virus is present to initiate wind borne infection (Radostits *et al*., 2006). Therefore, the probability of transmission of FMDV from infected bull to healthy bulls in the feedlots is assessed to be high (low uncertainty).

Photograph: Gezahegn Alemayehu

Figure 7: Bulls freely move in barn and share feed and water

Exposure pathway 2: exposure of bulls to FMD from scavengers

Semi-structured interview survey results indicated that the major disposal practices at feedlots is throwing carcasses into shallow pits or leave it on open air (93.5%) where scavengers can easily have accesses to carcasses and transmit the virus to feedlots mechanically or biologically. Furthermore, this survey indicated that scavengers such as vultures, dogs, cats and rodents were scavenging near the feedlots and dump sites. The survey further indicated that 19.36% of feedlots were keeping dogs and in all feedlots cats and vultures can have easy access to the feedlots. The virus can survive for long period of time in viscera, bone marrow, blood and lymph nodes (Mckercher and Callis, 1983; Radostits *et al*., 2006). The virus can pass unchanged through the alimentary tracts of birds which may thus act as carriers and transport infection for long distances (Radostits *et al*., 2006). This fact indicated that vultures can play a role in the transmission of the disease. Dogs and cats may also play a role in transmitting the virus mechanically by carrying the infective material from disposed area to feedlots environments. Rodents such as rats and mice may also play role in transmission of the virus because they show some level of susceptibility for the virus (Aftosa, 2007). However, the interaction of scavengers and bulls in the feedlots is rare. Therefore, the probability of transmitting the virus through scavengers is low (medium uncertainty).

Exposure pathway 3: exposure of bulls to FMD from staff

The hygienic practice of staff, who comes in contact with live and dead bulls was assessed. The assessment revealed that the probability of contamination of staff coming in contact directly with bulls for several reasons at all stages of the production cycle including tagging, prophylaxis treatments, vaccinations, medication of sick animals, blood sample collections and disposal of dead bulls could be high. Indirect contacts also occur during feeding and watering. The analysis of SSI revealed that 83.3% of the staff working in feedlots have direct contact with bulls. In 100% of feedlots observed, all staffs do not use any protective clothes while handling dead bulls and also do not use sanitary and disinfection facilities to avoid contamination. Staff hands, clothes or shoes soiled with excretions from infected bulls and carcasses can also be the source of infection. The virus can survive for 24 -28 hours in the human respiratory tract (Radostits *et al*., 2006; Aftosa, 2007). The virus may also persist for over 1 year in contaminated premises for 10-12 weeks on clothing and feed, and up to a month on hair (Radostits *et al*., 2006). Therefore, bulls could be infected directly by contaminated hands, aerosol and indirectly by ingestion of feed. Thus, the probability of transmitting the virus through contaminated staff is medium (low uncertainty).

Summary of exposure assessment of FMD

Table 5 presents the risk estimates for all the exposure pathways. The probabilities for the pathways range from low to high. The overall risk estimate for the bulls in the feedlots become infected by FMDV after the release of the virus by an infected bull in the value chain is thus high (low uncertainty). Therefore, the exposure of bulls in the feedlots to FMDV after the release of the virus by an infected bull in the value chain does occur very often.

Table 5: Summary of exposure assessment of FMD

Risk Pathway	**Risk Category**	**Uncertainty**
Probability of infection of bulls in the feedlot after exposure to FMDV from an infected Borena bull	High	Low
Probability that infected or contaminated scavengers transmit FMDV to bulls in the feedlots	low	Medium
Probability that feedlots staff handling live and dead bulls get contaminated with FMDV and transmit to bulls in the feedlot	Medium	Low
Overall risk estimate for exposure	High	Low

4.1.3. Consequence assessments of foot and mouth disease

Seroprevalence of foot and mouth disease in feedlots

From the total of 38187 bulls examined for the presence of antibodies to the 3ABC non-structural protein of FMD virus, 5536 (14.5%) were found positive. The seropositivity of FMD varied from site to site and the variations were statistically significant ($\chi2$=3.28, df= 9, p<0.001). The highest seropositivity was recorded in Meki (37.4%), and the lowest was recorded in Nahmaled site (3.1%) (Table 6).

Table 6: Seroprevalence of FMD in relation to site of feedlot operations

Site	**No of tested**	**No of positive**	**Seropositive (%)**	**95% CI**
Dera	2090	745	35.6	33.6-37.7
Modjo	484	16	3.3	1.7-4.9
Migra	12180	1468	12.1	11.5-12.6
Wanji	2136	77	3.6	2.8-4.4
Koshe	6399	888	13.9	13.0-14.7
Meki	3544	1327	37.4	35.8-39.0
Awash Melkasa	2417	518	21.4	19.8-23.1
Awash Sebat	4338	335	7.7	6.9-8.5
Nahmaled	3469	106	3.1	2.5-3.6
Adami Tulu	1130	56	5.0	3.7-6.2
Total	38187	5536	14.5	14.1-14.9

$\chi2$=3.28, df= 9, p=0.000

Similarly, there was statistically significant ($\chi2$=4.55, df=9, p<0.001) difference between months of the year with highest seropositivity on July (36.3%) and lowest was recorded on April (3.8%) (Fig.8).

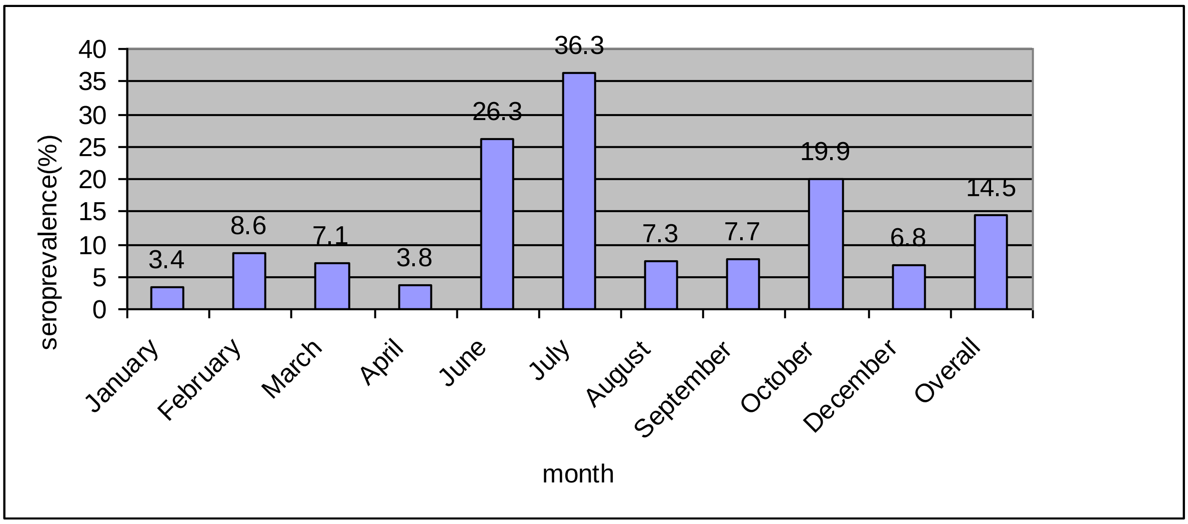


Figure 8: Monthly seroprevalence of FMD in feedlots in 2011

Economic loss estimation from foot and mouth disease

Direct economic loss caused by FMD was calculated based on FMD rejection rate from international market. According to FMD serology result, 14.5% of bulls in the feedlots were found positive for FMD and subsequently rejected from international markets. Markets assessment during study period revealed that, average 375kg bull was sold with 600USD (1.60 USD/Kg) average price at terminal markets for export. Therefore, the total economic loss due to FMD rejection from international market was estimated to be 3,322,269 USD which is equivalent to 56,345,682.24 ETB (1USD= 16.96 ETB). On average each 40 business owner participating in finishing of bulls destined fro export loss 83,057 USD (1,408,647 ETB) due to FMD in 2011.

4.2. Risk assessment of lumpy skin disease

4.2.1. Release assessment of lumpy skin disease

The pathway in which LSD could be introduced to feedlots through Borena bull in market chain is similar with pathway design for FMD as shown in Figure 5. According to SSI result 100% of feedlot operators preferred young Borana bulls (three to four years old) for fattening to export. The survey further indicated that 80.6% of feedlot operators (n=31) use Borena markets as the main source of bulls and 19.4% feedlots operators used Dera and Adama markets for purchasing Borana bulls for their feedlots.

Probability of Borena cattle in the market chain infected with LSD

Scientific literatures indicated that LSD was maintained endemically in Borena pastoral system and outbreaks occurred almost every year (Gari *et al.*, 2010). Rufael *et al*. (2008) also indicated that LSD was one of important disease in Borena cattle next to CBPP and FMD. All ages and types of cattle are susceptible to LSD (Radostits *et al.*, 2006; Vorster and Mapham, 2008). There is no national control and prevention strategy designed for LSD control (MoA, 2010). Lumpy skin disease outbreaks were controlled in Borena Zone by mass vaccination of the risky populations following the reports of its occurrences. However, as result of transport and communication problems, poor recording and documentation system, the reporting rate of LSD outbreak is low. Furthermore, financial and logistic problems were found to be main deep-rooted sources of limitation for responding fully and immediately to LSD outbreak reports (Bayissa and Bereda, 2009). Number of bulls purchased per market varied to a great extent based on type of markets. The bulls were transported using small trucks. The bulls can get infected at markets, collection sites and during transportation, increasing the probability of bulls reaching the feedlot in and around Adama shedding the virus. Taking into consideration the prevalence of LSD in Borena Zone and susceptibility of Borena bulls to the disease, the probability that an infected bull enters to the market chain is high (low uncertainty).

Probability of infected Borena bull not detected in the market chain

The incubation period under field conditions is 2-4 weeks and 7-14 days following experimental challenge (Radostits *et al.*, 2006). The characteristic skin nodules of LSD are seen between 7 and 19 days after virus inoculation. According to SSI results, average time spent on transportation from production areas to feedlots in Central Ethiopia is 1.65 days. Since bulls from production area to the feedlots spent less than 7 days, the likelihood of an infected bull without clinical sign undetected along the market chain is very high. Markets survey indicated that at various points in market chain from primary markets to feedlots in Central Ethiopia there were no veterinarian performing pre-purchase inspection and selection for quality assurance and certification for live cattle. The traded animals were not subjected to any test before they were moved into feedlots. Pre-purchase inspections along the market chain have been conducted by traders or purchaser groups without necessary animal health knowledge. According to SSI results, about 87.1% of operators have a trend of buying animals as batch. Buying animals as batch could increase the probability of an infected bull with mild infection to pass undetected along the market chain. The probability of not detecting the infected bull under the specified conditions is therefore assessed to be very high (low uncertainty).

Probability of lack of containment of the LSD virus

According to SSI result, pre-purchase inspection by purchasers group involves a visual and physical evaluation of bulls while moving freely in the markets. Personal observation indicated that, in 93.5% of feedlots dead bodies disposed in shallow pits near by feedlots or throw in open air where insects have easy accesses to disposed carcasses thus facilitating the transmission of the disease. Lumpy skin disease infected bulls were isolated in 83.9% of feedlots observed; however, none of isolation pens were insects proof with very high probability of viral transmission through mechanical vectors such as *Stomoxys spp*. and mosquitoes (Kitching and Mellor, 1986; Chihota *et al*., 2001). In 100% of surveyed feedlots, staffs do not use any protective cloths while handling the cattle and also do not use sanitary and disinfection facilities to avoid contamination. Generally, there could be an introduction of unobservable LSD infection via traded bulls; contaminated equipments and contaminated staffs. The facility would not help to identify and exclude the risk from introduction of the virus to feedlots. Thus, due to lack of biocontainment of the virus along the value chain, the probability of undetected infection entered to the feedlots is considered to be high (low uncertainty).

Summary of release assessment for LSD

The analysis results revealed that the overall risk for the release of LSDV in feedlots is estimated to be high (low uncertainty). Release pathways probabilities vary from high very to high (Table 7). Therefore, according to Table 2 interpretation, the probability of LSDV release into feedlots by traded bulls in the market chain occurs very often.

Table 7: Summary of release assessment for LSD

Risk Pathway	Risk Category	Uncertainty
Probability of Borena bull in the market chain is infected with LSD	High	Low
Probability of infected Borena bull is not detected while passing along the market chain	Very high	Low
Probability of lack of biocontainment of the virus within the facility along the value chain	High	Low
Overall risk estimate for release	High	Low

4.2.2. Exposure assessment of lumpy skin disease

Assuming that LSD has been introduced into the feedlot through infected bull passing along market chain, the bulls in the feedlots could get infected indirectly (Rovid, 2008a). The pathway through which bulls in the feedlots could be exposed to LSDV is presented in Fig.9.

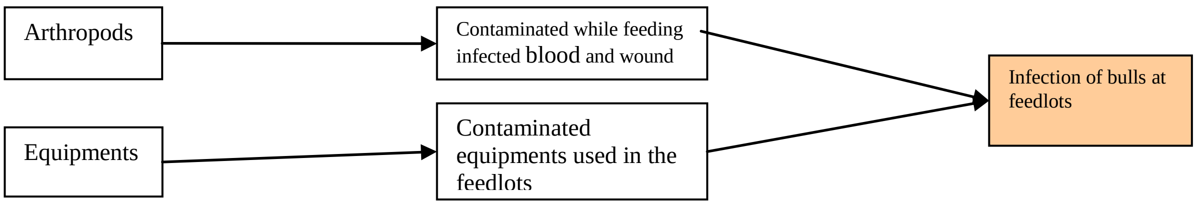


Figure 9: Exposure pathway of LSD

Exposure pathway 1: exposure of bull to LSDV from blood- feeding arthropods

Literatures indicated that the transmission of LSDV is believed to occur mainly by blood-feeding arthropods (Weiss, 1968; Kitching and Mellor, 1986; Chihota *et al.,* 2001). According to feedlot operators, LSD outbreaks in feedlots occurred during rainy season when mosquitoes and other flies population increases. Different studies indicted that LSDV is mechanically transmitted by mosquitoes (e.g. *Culex mirificens, Aedes natrionus and A. aegypti*)) and flies (e.g. *Stomoxys calcitrans* and *Biomyia fasciata*) (Weiss, 1968; Kitching and Mellor, 1986; Yeruham *et al.,* 1995; Chihota *et al.,* 2001; Vorster and Mapham, 2008). According to SSI results, vaccination of bulls started a week after the final bull purchased have entered the feedlots and registered by quarantine service. However, the duration of time from introduction of the first batch of bulls to vaccination is sufficient for transmission of the disease to susceptible bulls by biting insects. Furthermore, SSI results indicated that 71% of feedlots operators have doubt on the efficacy of the LSD vaccine. Infected bulls were isolated in 85% of the feedlots. However, biting insects have easy accesses to the isolated infected and healthy bulls. Therefore, the probability of transmitting the virus is very high. Since temporal LSD occurrence was associated with increase in the biting-fly population (Gari *et al*., 2010), the probability of infection of bulls in a feedlot after exposure to LSDV from blood feeding arthropods during rainy season is very high (medium uncertainty).

Exposure pathway 2: exposure of bulls to LSD from equipments

According SSI results, as part of SPS requirements and rules and regulations of animal quarantine, it is mandatory to vaccinate all bulls in the feedlot destined for export for six diseases and deworm at least once. The common method of vaccination and deworming are subcutaneous injection. Semi-structure interview results further indicated that only 29% of feedlot operators use their own veterinarian for the treatment of sick animals. The rest 71% operators use mobile veterinarians with higher probability using contaminated equipments between feedlots. Contamination of equipment happens mainly via blood, crust of skin lesion, saliva, nasal and lachrymal discharges (Weiss, 1968). Lumpy skin disease virus is remarkably stable and surviving for long periods at ambient temperature, especially in dried scabs. The virus is very resistant to inactivation, surviving in necrotic skin nodules for up to 33 days or longer, desiccated crusts for up to 35 days, and at least 18 days in air-dried hides (Rovid, 2008a). If proper needle hygiene was not practiced, needles contaminated with virulent LSDV during the actual vaccination and treatment procedure serve as vehicle for transmission of the virus (Carn and Kitching, 1995; Magori-Cohen *et al*., 2012; Tuppurainen and Oura, 2012). According to personal observation, biosecurity levels in most feedlots were very poor; this makes them to be very vulnerable to disease incursions. Survey further indicated that almost all feedlots are unlikely to disinfect or thoroughly clean and dry their equipment. The likelihood of exposure of bulls in the feedlots to LSDV through unsterilized needles is therefore considered to be high (low uncertainty).

Summary of exposure assessment for LSD

The risk estimates for all the exposure pathways is presented in Table 8. The probabilities in the pathways range from high to very high. The overall risk estimate for exposure of bulls to become infected by LSDV after the release of the virus by an infected bull is thus very high (medium uncertainty). The exposure of bulls to LSDV after the release of the virus by an infected bull in the value chain occurs almost certainly (Table 2). It should be noted also that this qualitative probability estimate is associated with a medium level of uncertainty. This level of uncertainty is due to lack of information on type of blood feeding arthropods present in feedlots areas.

Table 8: Summary of exposure assessment for LSD

Risk pathway	Risk Category	Uncertainty
Probability of infection of bulls in the feedlots after exposure to LSDV from contaminated blood- feeding arthropods.	Very high	Medium
Probability of infection of bulls in the feedlots after exposure to LSDV from contaminated equipments.	High	Low
Overall risk estimate for exposure	Very high	Medium

4.2.3. Consequence assessment of lumpy skin disease

Clinical and epidemiological investigation of LSD outbreak

During study period, all bulls were carefully examined for presence of characteristic clinical signs of LSD. Affected animals showed severe clinical signs (Fig.10), characterized by generalized skin nodules of 2-5 cm in diameter (Fig.10A1), enlarged peripheral lymph nodes and edema of the dependent parts (brisket and forelegs) (Fig.10 A2), and ocular discharge(Fig.10 A3). Majority of the affected population was observed with variable degree of lameness (Fig.10B1) that accompanied with edema of limbs with the progression of disease the nodules became necrotic, and eventually a deep scab formed (sit-fast) (Fig.10B2).

Photograph: Gezahegn Alemayehu

Figure 10: characteristic clinical signs of LSD

(A1). Generalized skin nodules, (A2). Brisket edema, (A3). Lameness and edema of leg , (B1).Ocular discharge, (B2). Necrotic nodules and deep scab formation (sit-fast)

From the total of 11189 bulls observed during outbreak investigation of LSD in six sites of feedlot operation in and around Adama, 681(6.1%) and 204 (1.8%) bulls were found affected and dead with LSD, respectively. Analysis of the outbreak statistics considering site as risk factor (Table 9) revealed a significant difference in morbidity rate ($\chi2=2.514$, df=5, $p<0.001$)

among all the sites of feedlots operations with highest values observed in Koshe (11.9%) and lowest value absorbed in Dera (1.4%). Mortality rate were also significantly different ($\chi 2$= 1.68 df=5, p<0.001) among all the sites of operations with highest values observed Koshe (4.8%) and lowest value absorbed in Dera (0.5%). The overall case fatality of the disease was 30% with significant difference among all feedlot operation sites ($\chi 2$= 32.67 df=5, p<0.001). The highest case fatality was recorded in Koshe (40.5%), and lowest case fatality was recorded in Nahmaled (15.8%).

Table 9: Morbidity, mortality and case fatality rates of LSD in relation to site

Site	**PAR**	**New case**	**Dead**	**Morb. (%)**	**Mort. (%)**	**CFR(%)**
Boku	817	89	25	10.9	3.1	28.1
Dera	1050	15	5	1.4	0.5	33.3
Koshe	2263	269	109	11.9	4.8	40.5
Migra	1771	74	24	4.2	1.4	32.4
Nahmled	4055	158	25	3.9	0.6	15.8
Wanji	1233	76	16	6.2	1.3	21.1
Total	11189	681	204	6.1	1.8	30

PAR=Population at risk; Morb. =Morbidity; Mort. =Mortality; CFR= Case fatality rate

Direct economic loss estimation due to LSD

Direct economic loss caused by LSD was calculated based on LSD mortality rate and rejection rate of bulls from international markets due to detected LSD infection. According to clinical and epidemiological LSD outbreak investigation result, 1.8% of bulls were dead and 4.1% were rejected. According to Adama plant and animal quarantine service record, 18864 bulls were at risk of death and rejection during the LSD outbreak. Terminal market survey indicated that, a bull with 375kg average weight was sold with 600USD average price (1.60 USD/Kg). Total financial loss due to LSD death of bulls in the feedlot during the outbreak (June-December 2011) was estimated 204,000 USD and 464,054.4 USD estimated loss from LSD rejection. Therefore, the total economic loss due to LSD death and rejection was estimated to be 668,054.4 USD which is equivalent to 11,330,202.6 ETB (1USD= 16.96 ETB). On average each 20 assessed feedlot owner lost 33,403 USD (566,515 ETB) due to LSD during six month of study period.

4.3. Risk assessment of contagious bovine pleuropneumonia

4.3.1. Release assessment of contagious bovine pleuropneumonia

The pathway in which CBPP could be introduced to the feedlots through Borena bull in market chain is similar with pathway design for FMD as shown in Figure 5. According to SSI result 100% of feedlot operators preferred young Borana bulls (three to four years old) for fattening to export. Survey further indicated that, 80.6% feedlot operators (n=31) use Borena markets as the main source bulls and 19.4% feedlots operators used Dera and Adama markets for purchasing Borana bulls for their feedlots.

Probability of Borena cattle in the market chain infected with CBPP

According to different literatures, Ethiopia is one of east African countries in which CBPP is endemically maintained all over the country with 25% morbidity and more than 10% mortality (Masiga *et al*., 1996; Tambi *et al*., 2006). Borena Zone as a whole infected since long time, is an endemic area (Afework, 2002). According to result obtained by Issa (2004) and Roger and Yigezu (1995) prevalence rates of 9.4 % and 74% were recorded in Borena cattle, respectively. Rufael *et al*., (2008) also indicated that CBPP was number one important disease in Borena cattle. Borena zebu (*Bos indicus*) cattle are fully susceptible to the disease (Masiga and Read, 1972). There is government strategy in animal health provision of preventive services through mass vaccination of CBPP (Bayissa and Bereda, 2009). Borena Pastoral Area Development Office record analysis result revealed that more than 80% of cattle in the Borena Zone were vaccinated for CBPP in 2010/2011. Annual mass vaccination program might decrease the seroprevalence of the disease (Masiga and Domenech, 1995). However, taking into consideration the long time endemic maintenance of the disease in Borena Zone and susceptibility of Borena cattle for CBPP, the probability that an infected bull entered to the market chain is medium (low uncertainty).

Probability of infected Borena bull not detected in market chain

The incubation period for CBPP is difficult to define. This period varies from 20 to 123 days (Rovid, 2008b). According to SSI results, average time spent on transportation from production areas to feedlots in Central Ethiopia was 1.65 days. Since cattle from production area to the feedlots spent less than 20 days, the likelihood of an infected animal with out clinical sign undetected along the market chain is high. Markets survey indicated that at various points in market chain from primary market to feedlots in Central Ethiopia there was no veterinarian conducting pre-purchase inspection and selection for quality assurance and certification for live cattle. The traded animals were not subjected to any tests before they were moved into feedlots. Pre-purchase inspections along the market chain have been performed by traders or purchaser groups with out necessary veterinary skills and knowledge. Furthermore, diagnosis of CBPP in a single animal may be difficult and 50% of the animals develop subclinical disease (Masiga *et al*., 1996). Semi-structure interview results further indicated that 87.1% of operators have a trend of buying animals as batch. Buying animals as batch could increase the probability of an infected bull with mild infection to pass undetected along the market chain. The probability of not detecting the infected bulls under the specified conditions is therefore assessed to be very high (low uncertainty).

Probability of lack of containment of *Mmmsc* bacteria in market chain

Markets survey indicated that pre-purchase inspection by purchasers group involves a visual and physical evaluation of animals while moving freely in the market. According to survey results, 83.9% feedlots have isolation pens, however, 76% of pens were found adjacent to pen where healthy bulls were kept with possibility of bacterial transmission from infected bulls to healthy bulls by means of aerosols (Masiga *et al*., 1996). Generally, there could be an introduction of unobservable CBPP infection via traded bulls. The facility would not help to identify and exclude the risk from introduction to the feedlots. Thus, due to lack of biocontainment of the bacteria within the facility of the market chain, the probability of introduction of the bacteria into the feedlots is considered to be high (low uncertainty).

Summary of release assessment of CBPP

The findings of this assessment as outlined in Table 6 suggest that the overall risk for the release of *Mmm*SC bacteria in feedlots was estimated as medium with low uncertainty. Release pathways probabilities vary from medium to very high. Therefore, according to interpretation in Table 2, the probability of *Mmm*SC bacteria release into feedlot by traded bulls in the market chain occurs regularly.

Table 10: Summary of release assessment of CBPP

Risk pathway	Risk category	Uncertainty
Probability of Borena bull in the market chain is infected with CBPP	Medium	Low
Probability of infected Borena bull is not detected while passing along the market chain	Very high	low
Probability of lack of biocontainment of the bacteria within the facility along the market chain	High	Low
Overall risk estimate for release	Medium	Low

4.3.2. Exposure assessment of contagious bovine pleuropneumonia

Assuming that CBPP agent has been introduced into the feedlot through infected bull passing along market chain, other bulls in feedlots could get infected directly (Rovid, 2008b). The pathways through which bull are exposed to *Mmm*SC bacteria is shown in Fig.11.

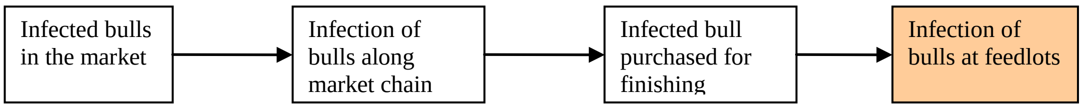


Figure 11: CBPP exposure pathway

Exposure pathway1: Exposure of bulls via infected bull

According to SSI results, the bulls are usually introduced into feedlots without quarantine. The transmission of the disease through contact between newly introduced and previously purchased bulls is highly likely as bulls are free to move in the barn (Fig. 7) and share common feed and water which increase direct contacts between healthy and diseased bulls or at incubation stage. Interview with feedlots operators indicated that, vaccination of bulls started two week after the final bull purchased have entered the feedlots and registered by quarantine service. The duration of time from introduction of the first batch to vaccination is sufficient to transmit the disease to susceptible bulls. *M. mycoides* SC is mainly transmitted from animal to animal through aerosols. In 16.1% of observed feedlots there was no isolation pen for sick bulls. Furthermore, in 76% observed feedlots the isolation pens were constructed adjacent to healthy bulls' pens. Therefore, there is possibility of the bacterial transmission from infected bulls to healthy bulls by means of aerosols (Masiga *et al*., 1996). Carrier animals, including subclinically infected cattle, can retain viable organisms in encapsulated lung lesions (sequestra) for up to two years. These bulls may shed organisms, particularly when stressed. Therefore, the probability of transmission of CBPP from infected bull to healthy bulls in the value chain is assessed to be high (low uncertainty).

The overall risk estimate for the bulls in the feedlots become infected by CBPP after the release of the bacteria by an infected bull in the value chain is thus high (low uncertainty). Using the interpretation given in Table 2, the exposure of bulls in the feedlots to after the release of the *Mmm*SC by an infected bull in the value chain does occur very often.

4.3.3. Consequence assessment of contagious bovine pleuropneumonia

Seroprevalence of contagious bovine pleuropneumonia

From the total of 38187 bulls examined for the presence of antibodies using c-ELISA, 150 (0.4%) were found positive. The seropositivity of CBPP varied from site to site, and the variations were statistically significant ($\chi2=63.45$, df= 9, $p<0.001$). The highest seropositivity was recorded in Meki (1.1%), and the lowest was recorded in Modjo site (0.0%) (Table 11).

Table 11: Seroprevalence of CBPP in relation to site of feedlot operation

Site	No of tested	No of positive	Seropositive(%)	95% CI
Dera	2090	14	0.7	0.3-1.0
Modjo	484	0	0.0	0.0-0.0
Migra	12180	38	0.3	0.2-0.4
Wanji	2136	4	0.2	0.0-0.4
Koshe	6399	19	0.3	0.2-0.4
Meki	3544	40	1.1	0.8-1.5
Awash Melkasa	2417	6	0.2	0.0-0.4
Awash Sebat	4338	15	0.3	0.2-0.5
Nahmaled	3469	10	0.3	0.1-0.5
Adami Tulu	1130	4	0.4	0.0-0.7
Overall	38187	150	0.4	0.3-0.5

$\chi2=63.449$, df= 9, $p=0.000$

Similarly, there was statistically significant ($\chi 2$=23.73, df=9, p= 0.005) difference between months of the year with highest seropositivity on July (0.7%) and lowest recorded on June (0.1%) (Fig. 12).

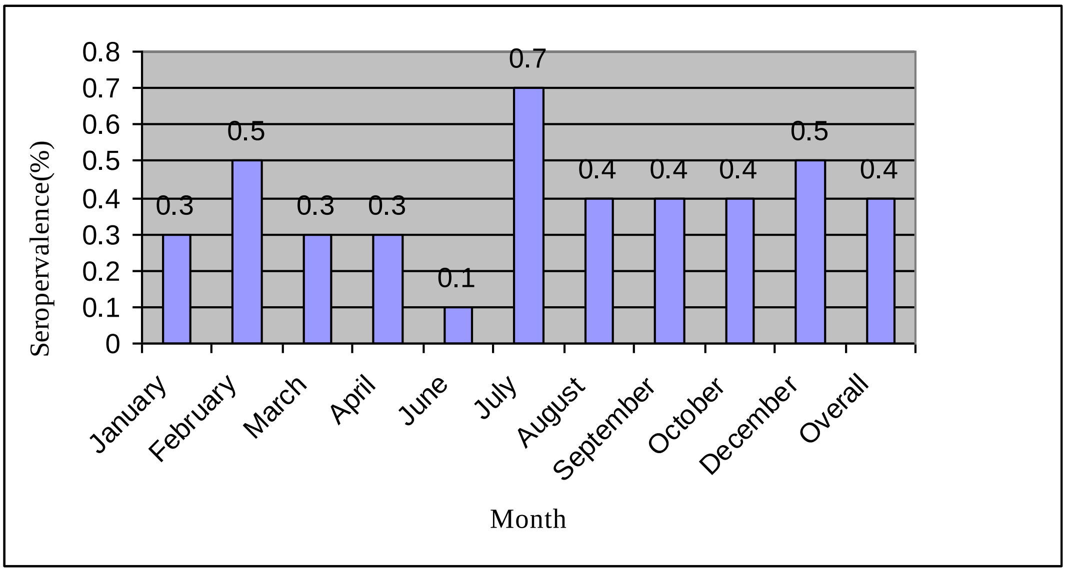


Figure 12: Monthly seroprevalence of CBPP in feedlots in 2011

Economic loss due to CBPP

Direct economic loss caused by CBBP was calculated based on CBPP rejection rate from international market. According to CBPP serology result, 0.4% of bulls in the feedlots were found positive for CBPP and subsequently rejected from international markets. Market assessment during period revealed that average 375kg bull was sold with 600USD (1.60 USD/Kg) average price at terminal markets for export. Therefore, the total economic loss due to CBPP rejection from international market was estimated to be 91,649 USD which is equivalent to 1,554,367 ETB (1USD= 16.96 ETB). On average each 40 business owner participating in finishing of bulls destined for export lost 2,291.2 USD (38,859 ETB) due to CBPP in 2011.

4.4. Participatory assessment of perceptions of feedlots operators to the risks

The result of semi-structured interviews revealed that informants groups participating in finishing of Borena cattle for export were able to describe diseases and ranked them based on mortality, rejection from international market, market value of diseased bulls in local market, feed conversion rate, frequency of occurrence and the ease for control. The result of pair-wise ranking revealed that LSD was ranked with top for its overall importance in six groups out of ten informant groups and FMD ranked second in five sites and first in four sites and third in one site. Pasteurellosis, bloat and CBPP ranked third, fourth and fifth, respectively (Annex 6).

The results of pair-wise comparisons were the basis for further characterization and selection of diseases for matrix scoring. The results of matrix scoring for transboundary animal diseases and other diseases are presented in Table 12. Strong agreement (W = 0.837 to 0.989; P=0.000) was observed among the 10 informant groups with group size varied from 4-11 for all disease indicators. The informant groups indicated that skin lesion; rejection from international market, mortality, decrease feed conversion rate, lameness, and decrease market value in local market and morbidity were common indicators of LSD. They also indicated that salivation, rejection from international market and lameness were most important indicators of FMD and coughing for CBPP.

Table 12: Summarized matrix scoring of cattle disease by feedlot operators

Indicators (W)	Diseases				
	Bloat	FMD	LSD	CBPP	Pastuerellosis
Skin lesion (W = 0.884)	0(0-0)	0(0-2)	25(24-25)	0(0-0)	0(0-0)
Rejected (W =0 .981)	0(0-0)	14(12-15)	9(9-22)	2(1-3)	0(0-0)
Mortality (W = 0.922)	6(3-7)	0(0-0)	10(9-13)	1.5(0-6)	8(6-8)
Coughing (W=0.995)	0(0-0)	0(0-1)	3(2-3)	2(12-16)	10(6-11)
Salivation (W=0.955)	0(0-0)	15(14-15)	0(0-0)	2(0-5)	9(5-10)
Occur at the begging of finishing period (W=0.890)	12.5(11-12)	0(0-0)	0(0-1)	0(0-2)	12(12-13)
Decrease feed conversion rate (W =0 .885)	0(0-0)	3(2-5)	15(14-20)	5(2-7)	0(0-3)
Lameness (W = 0.960)	0(0-0)	10 (9-13)	15(12-16)	0(0-0)	0(0-0)
Decrease market value (W= 0.837)	0(0-0)	1(0-2)	24(20-25)	1(0-3)	0(0-0)
Sudden death (W = 0.880)	12(9-15)	1(0-4)	0(0-0)	2(0-5)	10(9-12)
Morbidity (W = 0.960)	0(0-0)	7(6-12)	10.5(8-13)	5(1-6)	2.5(0-4)
Response to treatment (W =918)	3(0-3)	0(0-1)	2(0-3)	8(8-10)	12(11-15)

Number of informants groups =10; W= Kendal coefficient of concordance; P- value is <0.001 for all W. Median scores (with minimum and maximum scores) were shown in each cell of the table.

4.5. Risk estimation of prioritized transboundary diseases

The likelihood of introduction of prioritized TADs to feedlots from infected bull passing along market chain ranges from medium to high. There is high probability FMD and LSD introduction to the feedlots and medium probability for CBPP. The likelihood of infection, as a consequence of exposure also high except for that of LSD very high consequence of exposure in the presence of blood feeding arthropods. Then, the likelihoods of diseases occurrence from the release and exposure range from medium to high (Table 13). As a consequence, the overall prevalence of FMD and LSD is more than 5% that need control intervention. The total estimated annual (2011) economic loss due to three prioritized transboundary diseases was estimated to be 4,081,972.2 USD which is equivalent to 69,230,248.51 ETB (1USD= 16.96 ETB). The economic losses estimation also revealed that more than 20.8% loss was recorded from total income of business due to the occurrence of these three diseases. Therefore, the risk estimation is greater than negligible and risk management measures may be justified.

Table 13: Risk Estimation of Prioritized Transboundary Diseases in feedlots

Disease	**Risk of Release**	**Risk of Exposure**	**Disease Occurrence**
FMD	High	High	High
LSD	High	Very high	High
CBPP	Medium	High	Medium

5. DISCUSSIONS

The application of risk analysis in the animal and veterinary public health fields is a relatively new and evolving discipline that has become increasingly important after the establishment of the agreement on the application of sanitary and phytosanitary measures (SPS agreement), being largely employed to provide importing countries with an objective method of assessing disease risks associated with the importation of animal products (Murray *et al*., 2004). Nevertheless, it is also applicable to other areas of animal disease control and, more widely, to other risky decision contexts (Fahrion *et al*., 2008; FAO, 2010; Taylor *et al.*, 2010; FAO, 2011). In this sense, the risk assessment framework can help in identifying risk hotspots in the value chain, which is useful to optimize targeted surveillance and control measures (Taylor *et al.*, 2010; FAO, 2011). Considering our assumptions, some traded bulls in the market chain were identified as being of higher risk for the introduction and spread of prioritized TADs in the feedlots because of their place of origin, certification system in the market chain, facilities in the chain to exclude the risk and awareness of the actors in the chain towards the risks. Many of live cattle exported from Ethiopia are originated from Borena pastoral system where FMD, LSD and CBPP epidemics have been reported (Roger and Yigezu, 1995; Issa, 2004; Rufael *et al*., 2008; Gari *et al*.,2010; Bayissa *et al*., 2011; Mekonen *et al.,* 2011). Furthermore, these animals were moved from production areas to the feedlots with out certifications and any test. Pre-purchase inspections along the market chain have been conducted by traders or purchaser groups without necessary veterinary skills and knowledge and there are no appropriate holding facilities in the market chain that can assure containment of the agents upon release. Therefore, the overall risks range from medium to high as a result of high risk of introduction of FMD and LSD and medium risk for CBPP to market chain. These steps in the release risk pathways should be considered as being critical control points where appropriate intervention measures can be applied. The probabilities of bulls in the value chain becoming exposed to FMDV and *Mmm*SC bacteria after they are released by traded bulls in the market chain are considered to be high and very high for LSD virus. These are mainly due to the fact that biosecurity measures along the value chain are negligible which makes them to be very vulnerable to disease incursions.

As biological consequences, the overall seroprevalence of 14.5% reported for FMD in this study is indicative of its importance in feedlots business. The individual animal seroprevalence result obtained in this study was in close agreement with the previous findings from Andassa dairy farm (Mazengia *et al*., 2010) and Jijiga zone (Mohamoud *et al*., 2011) in which seropositivity of 14.6 and 14.05% were reported, respectively. On the other hand, the prevalence reported in this study is higher value than pervious reports of 8.18% (Molla *et al*., 2010) and 9.5% (Megersa *et al*., 2009) in South Ethiopia. The seropositivity finding of this study is lower than record of 21% in the Borana pastoral area (Rufael et al., 2008) and 26.5% in the country (Sahle, 2004). The lower prevalence of FMD in the feedlots than in Borena pastoral system might be due to the fact that bulls are purchased based on their good body condition and health. Thus, the probability of chronically ill animals with poor body condition entering the feedlots is therefore very low.

There was significant difference found between sites of feedlots operations with FMD prevalence of 37.4% and 3.1% at Meki and Nahmaled sites, respectively. This variation might be due to the difference of biosecurity measures the feedlots used. Similarly, there was statistically significant ($\chi 2=4.55$, df=9, $p<0.001$) difference between months of the year with highest seropositivity on July (36.3%) and lowest was recorded on April (3.8%). The relative low seroprevalence in April might be due to the fact that FMD virus transmission over considerable distance by aerosol is less effective in hot and dry condition of tropics (Hutber and Kitching, 2000). Therefore, the reported higher prevalence of FMD during cold and rainy month of July could be attributed to virus stability under such conditions (Klein *et al.*, 2008).

The presence of characteristic skin nodules and outstanding features of the LSD are best indicative of the occurrence of LSD at affected feedlots. The clinical picture of the disease includes such as generalized skin nodules, edema of the dependent parts, ocular discharge and lameness were in accord with those documented by Coetzer (2004), Brenner *et al*. (2006), Radostits *et al.* (2006), Kumer (2011), Gari *et al.* (2010) Salib and Osman (2011) and Body *et al*. (2012).

The magnitude and frequency of LSD occurrence varied across sites of feedlots operation during the study period. The observed LSD prevalence at animal level found in this study was 6.1% which was in close agreement with the previous findings from Nekemt area of 7.02% (Regassa, 2003) and 8.1% reported by Gari *et al.* (2010) in the country. Mortality (1.8%) observed during this outbreak was similar with previous reports by Salib and Osman (2011) in Egyptian cattle. The significant differences observed between the morbidity, mortality and case fatality rates in the six sites might be attributed to variations in availability of suitable condition for the presence of blood-feeding arthropods (Ali *et al*., 1990; Gari *et al.,* 2010) and difference in biosecurity practice used in the feedlots.

A seasonal characteristic of LSD occurrence implies that the transmission of the disease might be linked with the optimum season for the development of vector insect population (Kitching and Mellor, 1986; Chihota *et al*., 2001; Gari *et al.,* 2010). However, there are still little hard evidences for the specific insect vectors incriminated in the transmission of LDSV and may deserve further study to elaborate the principal vectors.

From the total of 38187 bulls examined for the presence of CBPP antibodies using c-ELISA, 150 (0.4%) were found positive. The present study is in close agreement with the previous seroprevalence record of 0.51% in Nigeria (Nawathe, 1992). On the other hand, the seropositivity finding of this study was lower than the overall seroprevalence of 10.3% reported by Mekonnen (2004) in Somali Region and 4% in West Wellega by Fikru, (2001). Higher seroprevalences were also recorded in previous studies in Borena Zone with 5.1% and 74% prevalence by Issa (2004) and Roger and Yigezu (1995), respectively. The lower seroprevalence in this study might be due to the fact that annual mass vaccination program might decreases the seroprevalence of the diseases at community level. This fact is supported by Masiga and Domenech (1995) in which annual mass vaccination has been used with good results in East Africa and much of West Africa. Bulls intended for finishing were purchased based on their good body condition and health, the probability of chronically ill animals with poor body condition is therefore very low. This might also account for lower prevalence of diseases in the feedlots. In Ethiopia antibiotic is used for the treatment of the disease for long time. This could lower seroprevalence of the disease by reducing a detectable serological response (OIE, 2009).

The seropositivity of CBPP varied between study sites and the variations were statistically significant ($\chi2=63.45$, df= 9, $p<0.001$). The highest seropositivity was recorded in Meki (1.1%), and the lowest was recorded in Modjo site (0.0%). This variation might occur due to the difference in biosecurity measures used in feedlots. Similarly, there was statistically significant ($\chi2=23.73$, df=9, p= 0.005) difference between month of the year with highest seropositivity on July (0.7%) and lowest was recorded on June (0.1%). The higher prevalence of the disease in rain month of July might be due to the fact that the disease is less prevalent in dry climates than in humid ones due to infected droplets can be inactivated by ultraviolet light as indicated by Provost *et al*. (1997).

The total annual (2011) economic loss due to prioritized TADs was estimated to be 4,081,972.2 USD which is equivalent to 69,230,248.5 ETB (1USD = 16.96 ETB). These losses were due to death of cattle from LSD and rejection of cattle from international market due to LSD, FMD and CBPP. The total estimated economic losses caused by three transboundary diseases in this study were 20.8% of the total income of the business owners from finished bulls. On average each business owner loss 33,403, 83,057 and 2,291.2USD in 2011 due to LSD, FMD and CBPP, respectively. This loss estimated for individual business owner might be more than estimated here since each operator could engage in finishing practice more than once in a year. Moreover, the feedlot operators also incurred costs associated with treatment of sick bulls and maintenance of the rejected animals. For example during the LSD outbreak, the feedlots operators tried to sell those rejected bulls for local butchers, However, no one need to buy those bulls due to the fact that the disease affects the flesh of the bulls. Therefore, the rejected bulls were held at feedlots for additional three to four months at a cost of the operators. The same is true for FMD and CBPP in which the rejected bulls further reconditioned for additional 2-3 months in order to compete with bulls from smallholder fatteners in the local markets. Due to this fact some feedlots operators drew down their working capital and were unable to resume their fattening activities at the time of this study (about 5 months after the outbreak). Hence, the introduction of trade sensitive diseases into feedlots can cause severe financial hardship and lead to the failure of the business. Furthermore, an outbreak of a disease such as LSD in the feedlots increases the risk facing individuals or firms considering entering the live cattle export industry, even in time when the disease may not be present.

The demonstrated negative impacts of the three prioritized TADs on the feedlots operators' are not the only consequence documented where financial impact assessment was conducted but also other downstream actors in the value chain, including livestock producers, traders, farm attendants, veterinarians, as well as other, non-agricultural sectors. If exports are to continue to increase, certainly national herd off-take continue to increase which enhance the income of producers. Similarly, the presence of a disease can affect consumer acceptance of animal products which will affect producer incomes, not only in the area in which the disease outbreak occurred but also elsewhere in the country. Impact of those diseases in feedlots may extend to these stakeholders participating in the value chain even if they do not own livestock. Feedlots focused at the export market, are an important employer of rural and urban workers with few marketable skills. Feedlots owners created employment opportunity for many veterinarians graduated from different universities in the country. The loss of export markets through a health problem in the feedlot industry of Ethiopia could result in a loss of employment for these workers. The effect would spill over to other suppliers of inputs including cattle feed suppliers and transport services.

Live cattle export from Ethiopia is currently largely feedlot-based. The introductions of TADs into feedlots certainly affect access to specific markets. For longer time Middle East markets are the traditional destination of Ethiopian live bulls. However, the current health status of Borena bulls in market chain unquestionably becoming a challenge for the country future live cattle exports opportunities to those countries. From Middle Eastern countries, Egypt and Yemen were the only importer of live cattle from Ethiopia during the study period. This fact signifies that share of Ethiopian has been declining in recent years while the competitors have been taking an increasingly larger share of the rapidly expanding market for live animals in terms of reliability of supply and terms of trade, quality and safety and other non-price factors. The main competitors of Ethiopia such as Australia, New Zealand, Brazil, India and Pakistan are already meeting the international SPS standards. As a result, bulls exported from Ethiopia fail to compete in international market especially in those importing countries having more strict measures. The repeated bans imposed by importing countries on livestock and meat export trade of Ethiopia signify a lack of confidence in the country’s export systems. The imposition of this type of trade ban and the endemic nature of FMD and other TADs in southern Ethiopia raises questions about the most appropriate ways to control the disease along the chain and also, ensure the safety of live cattle exported to other countries.

In this study, the participatory appraisal methods used indicated that cattle diseases that have transboundary importance were major problems in the Borena bull market chain for export. The participatory methods help to obtain insights on actors’ perspectives of risk. Strong agreement among informant groups implied that the prioritized diseases were commonly perceived risk in the studied segment of the chain. This indicated that the feedlots operators acquire knowledge of the risk introduced of their own context. Then feedlots operators take an action by their own to mitigate the risk through a continuous adaptive process, whereby decisions are made based on perceptions of the external environment such as market access, resources and the operators’ own attitudes and preferences. Indigenous practices and technologies can often be quite effective at decreasing risk (Grace *et al*., 2008). It is not necessarily only the factors affecting risk, but also the feedlots operators perceptions to the risk, that are crucial in decision-making. Market chain actors understanding of the risk and support for the decision making process are critical, especially in situations where the potential adverse outcome has serious health or economic consequences on a regional or national level. But sometimes it is neglected in preventing or managing the risks at community level which engender a bottom up approach planning and implementation of disease control programmes, to complement the more traditional top-down approach adopted by governments. On the other hand, the participatory approach give opportunities to identify the people involved (stakeholders) in the sector and examining how they operate and what determines their risk profiles. It also means of determining their resource bases, the profitability of their business and their alternative opportunities, as well as their constraints in terms of regulations, investment in human capital and infrastructure.

6. CONCLUSIONS AND RECOMMENDATIONS

The probabilities of release of transboundary diseases (FMD, LSD and CBPP) to the feedlots through traded Borena bulls in the market chain range from medium to high. The probabilities of exposure of bulls to transboundary diseases in the value chain vary from high to very high. The introduction and spread of these diseases along the value chain causes huge economic loss. This can lead to failure of the business and significant disruption of live cattle trade in international markets.

The result of semi-structured interviews revealed that informants groups participating in finishing of Borena cattle for export were able to describe diseases and ranked them based on different indicators. Strong agreement among informant groups implied that the prioritized diseases were commonly perceived risk in the studied segment of the chain.

The importance of risk assessment in the market chain beyond its ability to estimate the risks associated with the introduction of a given disease, lies in its use as a framework for organizing data. It can also be used as a tool for supporting future regulations and policy in the areas of international trade of animals and animal products.

On the basis of the above findings, the following recommendations are made to improve the functioning and efficiency of the market chain.

Two phase SPS certification system proposed by MoARD which enforces live cattle exporters to undertake pre-selection of bulls in local markets, followed by initial testing, vaccination, and quarantine of bulls for 21-day during the first phase and then quarantining and finished in a feedlot (phase 2) should be applied.

The capacity to diagnose and maintaining records of transboundary diseases at every step in the market chain are required to develop long-term predictive disease statistics.

Strategies to improve veterinary service delivery by field staff and laboratories should be designed. Improved veterinary health services will reduce disease incidence, mortality and morbidity and improve the quality of marketed animals. In the medium to long term, health facilities and laboratories need to be better equipped and the number of veterinary staff in the public and private sectors should be increased.

Regular and periodic complementary serological studies and evaluation of clinical records should be maintained to build a reliable disease diagnosis, reporting, prevention and control system.

An effective biosecurity plan such as proper disposal of carcasses, isolation of sick bulls and cleaning of all equipments should be designed and implemented in the feedlots to prevent spread of diseases.

Feedlot operators, livestock traders, dealers and marketers should be made aware on the route of transmission of transboundary diseases. Emphasis should be given to do the “right thing” about sourcing of animals from disease-free areas wherever possible; not to buy any sick stock; follow the rules of quarantine or identification of animals; and keeping records. The potential consequences of the occurrence of a disease on national and international trade should be emphasized.

Vaccination programme for transboundary diseases should base on detection of serotypes or subtypes circulating within the country to ensure that the most appropriate vaccine strains can be selected for use in the country. Vaccination should also be timed appropriately, taking into consideration seasonal animal husbandry practice and livestock movement patterns.

An integrated system approach involving value chain and risk analysis should be applied in research, extension and marketing to improve the effectiveness of diseases control in the market chains

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8. ANNEXS

Annex 1: Data required for release assessment of prioritized TADs by borena bull

No	**Release Assessment Pathway**	**Data Required**
1.	Probability that a bull in the market chain is infected with TADs	Prevalence of selected FMD, LSD and CBPP in borana pastoral system
		Susceptibility of cattle in the chain to these diseases
		Frequency and volume of bulls in the chain
		Time spent in the chain until it reach to fatting farm
2.	Probability that an infected bull is not detected while passing along the chain	Incubation period
		Susceptibility /potential as carrier
		Number/frequency/proportion of cattle inspected (clinically and /or swab)
		Compliance with veterinary inspection along the market chain
		Actions taken on infected cases or those found sick or dead on arrival
3.	Probability of lack of biocontainment of the agents within the facility of inspection point in the market chain	Presence of appropriate inspection facilities for cattle in the chain
		Presence of appropriate disposal methods
		Presence of isolation pen
		Safety procedures for handling fomites, live and dead bulls

Annex 2: Data required for exposure assessment of bulls in feedlots to TADs

No	**Exposure Assessment Pathways**	**Data Required**
1.	Probability of infection of bulls in the feedlot after exposure to FMD and CBPP from infected bulls entered the value chain	Opportunities for contact
		Susceptibility(vaccination status)
		Survival of the virus in the environment
		Virus shedding behavior
		Airborne dust dispersion
		Infectious dose required
		Infectiousness of exposure
2.	Probability that scavengers infected or contaminated with FMD have contact with bulls from carcasses of infected bulls ,and this contact leads to infection	Presence and abundance of scavengers around feedlots and disposal pits
		Disposal practice of dead bulls
		Access of scavenger to the feedlots
		Survival of the agents in disposed material and contaminated environment
		Biosecurity practice in the feedlots
3.	Probability that feedlots staff handling live and dead bulls get contaminated with FMD and transmit to health bulls	Number of people involved in handling live and dead bulls
		Live bulls handling and disposal practices (use of protective clothing and disinfectants)
		Level of contamination of staff hand, clothing and boots
		Survival of the virus in

		contaminated hand, clothing and boots
		Infectiousness of contacts
4.	Probability of infection of bulls in a feedlot after exposure to LSDV from contaminated equipments	Type equipment used
		Survival of the agents in contaminated equipments
		Frequency of contact of cattle with equipments
		Infectiousness of contacts
		Biosecurity practices (cleaning and disinfection)
5.	Probability of infection of bulls in a feedlot after exposure to LSDV from contaminated Arthropods	Presence and abundance of arthropods
		Survival of the agents in arthropods
		Susceptibility(vaccination status) of cattle
		Frequency of contact of bulls with arthropods
		Infectiousness of arthropods

Annex 3: Check list for field survey

Objective: To identify major cattle disease in the market chain and risk factors for introduction to market chain.

Activities**:**

- Identify major cattle disease using Participatory Epidemiology (PE) methods
    - Semi-structured interview
    - Pair-wise ranking exercise
    - Matrix scoring of diseases
- Validate informants' information and confirm some of the diseases
    - Repeat the participatory exercise with at least 10 groups
    - Make clinical examination at the field
- Observe trading system in the market

i. Overall data

- How long you have been in the business?
- What are your initial sources of finance?
- Education level
- Is any formal registration process required to establish feedlots?
- Are there any written records of activities?

ii. Supply Pattern

- Markets used for purchasing bulls
- Type and number of bulls purchased in the market
- Buying system in the market
- Marketing problems encountered while purchasing cattle

iii. Health problems

- Knowledge about specific animal characteristics in terms of health, quality, safety, and other criteria required by importers.
- Criteria used to screen animals in markets to assure quality and safety
- Major disease challenging the business
- Health plan- vaccination and medication protocols

iv. Biosecurity

- Rules for staff keeping in feedlots
- Boundary security
- Routines at feedlots
- Waste handling practices

Annex 4: Check list for evaluation of feedlots biosecurity level

Biosafety Measures	**Yes**	**No**	**Remark**
All in all out policy			
Never mix bulls from other feedlots			
Use of foot bath			
Separate receiving pen			
Far from human resident area			
Proper disposal of dead animals			
Protective close and cleaning			

and disinfection			
Pens with their partitioning			
Separate feed and water troughs			
Separate sick pen			
Feeding shades			
Emergency slaughter house			
Drainage system			
Contamination of feed and water troughs with manure or other dirt.			

Annex 5: Feedlot performance data record sheet formats

1. Feedlot ID ___________________________________
2. Owner Name _________________________________
3. Name of recorder______________________________
4. Phone number ________________________________
5. Site _______________________________________
6. Record sheet on entrance of bulls to the feedlots

Date of arrival	**No of bulls arrived**	**Origin of bulls**	**Mean of transport**	**Weak animal on arrival**	**No of dead bulls**	**Pen number allocated**

7. Individual animal disease situation record sheet

Date	**Tag No**	**Pen No**	**Clinical diagnosis result**	**Treatment received**	**Action taken**	**Remark**

8. Serological Test Results Record Sheet

No	**Site**	**Date of test**	**Total No of bulls**	**No of Seropositive bulls**	
				FMD	CBPP

9. Feedlot Performance Results Record Sheet

No	**Feedlot ID**	**Site**	**No cattle**	**No of diseased**	**Animal treated**	**No of death**	**No of rejected**	**No Sero-positive animal**

Annex 6: Summary of common cattle diseases prioritized by feedlot operators

Local Name of Diseases	**Equivalent English Name**	**Rank**
Fentata/gurebrebta	Lumpy skin diseases	1
Afte-gir/maz	Foot and mouth diseases	2
silisa / gororesa	Pasteurellosis	3
Menefat /Bokokusu	Bloat	4
Samba/sal	Contagious bovine pleuropneumonia	5
Ekeke/ chito	Mange	6
Gandy	Trypanosomosis	7
Chack	Foot rot	8
Ebach /Bulka	Abscess	9
Garra kassa/ tekimat	Enteritis	10
Mezger/silmi	Tick infestation	11
Abagorba	Black leg	12

9. CURRICULUM VITAE (CV)

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10. SIGNED DECLARATION SHEET

I, the undersigned, declare that the thesis is my original work and has not been presented for a degree in any University and that all sources of material used for the thesis have been duly acknowledged.

Name	Gezahegn Alemayehu Ayalew
Signature	______________________
Date of submission	______________________

This thesis has been submitted for examination with our approval as University advisors.

Advisors/Supervisors	Signature
Dr. Girma Zewde (DVM, PhD, Assoc. Prof.)	_________________________
Dr. Brehanu Admassu (DVM, MSc.)	________________________