ASSESSMENTS OF RISK FACTORS AND FINANCIAL IMPACTS OF LUMPY SKIN DISEASE IN SELECTED DISTRICTS OF TIGRAY AND AFAR REGIONAL STATES, NORTH EASTERN ETHIOPIA

M.SC. THESIS

BY

BIRHANU HAILU

June, 2012

Jimma University

Assessments of Risk Factors and Financial Impacts of Lumpy Skin Disease in Selected Districts of Tigray and Afar Regional States, North Eastern Ethiopia

M.Sc. Thesis

Submitted to the School of Graduate Studies

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In Partial Fulfillment of the Requirements for the degree of

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As *Thesis* Research advisor, I hereby certify that I have read and evaluated this thesis prepared, under my guidance, by Birhanu Hailu entitled "**Assessments of Risk Factors and Financial Impacts of Lumpy Skin Disease in Selected Districts of Tigray and Afar Regional States, North Eastern Ethiopia**" I recommend that it be submitted as fulfilling the thesis requirement.

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As member of the *Board of Examiners* of the *M.Sc.* Thesis Open Defense Examination, We certify that we have read, evaluated the thesis prepared by Birhanu Hailu and examined the candidate. We recommended that the Thesis be accepted as fulfilling the *thesis* requirement for the Degree of *Master of Science* in Veterinary Epidemiology.

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External Examiner Signature Date

STATEMENT OF THE AUTHOR

First, I declare that this thesis is my actual work and that all sources of materials used for this thesis have properly acknowledged. It has been submitted in partial fulfillment of the requirements for M.Sc. degree in Veterinary Epidemiology at Jimma University. I really declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate. Quotations from this thesis are allowable with correct acknowledgement of source.

Name: Birhanu Hailu Signature: -------------

Place: Jimma University, Jimma

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BIOGRAPHICAL SKETCH

Birhanu was born in 1986 from his father Hailu Hagos and from his mother Etsay Amare in Southern Zone, Tigray region, Northern Ethiopia in a district called Emba Alaje, a kebelle named as Sesat. He attended his primary school in Adishiho town starting 1994 and continuing his high school in Wolde Nigus Quiha senior secondary school and AtseYohannes Comprehensive School until 2004. After he completed his high school, he joined Mekelle University in 2004 and attended Veterinary Medicine until 2009. After graduation he worked in Semera Univesity as lecturer for one year. He joined Jimma University College of Agriculture and Veterinary Medicine to study his M.sc. in Veterinary Epidemiology from September 2010 to date.

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ABBREVIATIONS

ASL	Above Sea Level
BSL	Below Sea Level
CFT	Complement Fixation Test
CBPP	Contagious bovine Pleuroneumonia
CFSPH	Center for food security and public health
CI	Confidence Interval
CSA	Central statistical Agency
ELISA	Enzyme Linked Immunosorbent Assay
FAO	Food and Agricultural Organization
FMD	Foot and Mouth Disease
GDP	Gross domestic product
IAH	International Animal Health
IFAT	Indirect Fluorescent Antibody Test
IGAD	Inter- governmental Authority for Development
ILCA	International Livestock center for Africa
ILRI	International Livestock Research Institute
KSGPV	Kenyan Sheep and Goat Pox Virus
LSD	Lumpy Skin Disease
LSDV	Lumpy Skin Disease virus
NAHDIC	National Animal Health Diagnostic and Investigation Center
OIE	World Organization for Animal Health
OR	Odds Ratio

PA	Peasant association
PPR	Petedes Petitis Ruminants
PCR	Polymerase Chain Reaction
REST	Relief Society of Tigray
RVF	Rift Valley Fever
SGPV	Sheep and Goat Pox Virus
SNNPRS	Southern Nations, Nationalities, and People's Region
UAE	United Arab Emirate
WFP	World Food Program
VNT	Virus Neutralization Test
IAGID	Agar gel immune diffusion

ASSESSMENTS OF RISK FACTORS AND FINANCIAL IMPACTS OF LUMPY SKIN DISEASE IN SELECTED DISTRICTS OF TIGRAY AND AFAR REGIONAL STATES, NORTH EASTERN ETHIOPIA

ABSTRACT

A cross-sectional study was conducted from October 2011 to February 2012 in selected districts of Afar and Tigray regional states to determine the herd level prevalence of LSD and its associated risk factors, and to assess financial impacts of the disease and the benefits from its control. A retrospective questionnaires survey was used to collect data on epidemiology of the disease and production losses. Multistage sampling technique was used for the selection of study groups. Households and their respective herds were selected based on the willingness of the respondents to participate in the study. Financial estimation was done within the same study districts and PA with the former one based on purposive sampling of clinically affected animals. A total of 660 questionnaires were collected from the four study districts of which 393 questionnaire were administered to the selected herd owners and the remaining 267 questionnaires were administered to herd owners for financial impact estimations. Out of the collected 393 herds, 173 were found to be infected with LSD with the overall average herd prevalence of 44% (95%CI: 37-50). From 267 herds which comprise 3442 animals collected for financial estimations, 379 animals were affected by the disease. There was significant difference in the prevalence between regions and among the districts with ($\chi^2 = 8, p<0.05$ and $\chi^2=9.9, p<0.05$) respectively. Introduction of new animal to the herd, herd size and communal grazing and watering points were among the herds risk factors significantly associated with the prevalence of the disease. The cumulative incidence and mortality rate from the 267 herds selected for financial impacts assessments were found to be 11% (95% CI: 9.9-12) and 2 %(95% CI: 1.5-2.3) respectively. The estimated percentage production losses were 3.26%, 2.56% and 0.9% of milk loss, draft power and beef loss respectively and the losses associated with these diseases per head of cattle was birr 193.00 (10.9926 USD) and the net benefit obtained from the control of the disease was birr70.00 (3.98695 USD). Awareness should be created in herd owners to use vaccines and on the isolation of infected animals from the rest of the herds as well as in economic impact of the disease.

Keywords; *Lumpy skin disease, herd level prevalence, risk factors, cumulative incidence, financial estimation*

1. INTRODUCTION

Agricultural development play significant role in achieving one of the major goals of the global community for alleviation of poverty. Livestock production is one segment of the agriculture constituting means of improving living standards of the exponentially increasing poor farmers in many regions of developing world (Sere and Steinfeld, 1995; FAO, 2009). The purpose of keeping livestock in many of these developing nations has a multifunctional activity beyond the food security are to give valuable assets, serve as a store of wealth, collateral for credit and as a buffer during the time of crisis. In sub-Saharan Africa, it continues to play a crucial role in the livelihood of the low income rural communities, saving their lives using livestock as capital reserve (http://tinyurl.com/IGADLivelihoods;ILCA, 2000).

Eight-five percent of the Ethiopian populations are heavily dependent on the contribution of agriculture with a particular emphasis of livestock for multipurpose activity (Tegegn, 1998). Farmers from both the high and low land areas of the nation use livestock for the provision of draught power, source of feed, closing ,transport and provides cash incomes, manure for soil fertility and energy (CSA,2011). Ethiopia is among the developing nations in Africa with the largest livestock population with estimated number of 53.38 million cattle, 25.50 million sheep, 22.78 million goats, 6.21 million donkey, 2.08 million horse, 1.10 million camels, 0.39 million mules and 49.28 million poultry (CSA, 2011).

Though production of the livestock has multidimensional input, there are several hindering factors which can reduce their production and performance not to give the optimum production in tropics. The main reasons for such constraints are health problems, feed constraints and genetic potential as result of the environmental factors like high temperature and humidity, topographical structure of sloppy areas exposed to flood (Asseged, 2000;ILCA,2000). Among these important factors, the livestock sector is constrained by the widely distributed diseases in different species of animals. These diseases have multiple impacts, affecting the productivity of the animals, public health significance and loss of trade opportunities in the international trade. Out of the 15 world animal health organization notifiable diseases, some of them are endemic in the country, namely; foot and mouth disease, contagious bovine plueropneumonia, Petedes petitis ruminants , lumpy skin disease, sheep pox, African Horse Sickness and Newcastle Disease (Wondwosen, 2003). The prevalence of such disease in the country hinders from penetrating world livestock market.

Lumpy skin disease is among the most economically significant, emerging viral diseases. It is currently endemic in most Africa countries and expanded to Middle East region (Tuppurinen and Oura, 2012). It is disease with a high morbidity and low mortality rate. It affects cattle of all ages and breeds and causes significant economic problems as result of reduced milk production, beef loss and draft animals, abortion, infertility, loss of condition and damage to the hide (CFSPH, 2008). It is an acute infectious disease and become an important threat to livestock and dairy industry (Kumar, 2011). The disease is characterized by fever, nodules on the skin, mucous membranes and internal organs, emaciation, enlarged lymph nodes, edema of the skin, and sometimes death.

Lumpy skin disease is caused by the virus classified in capripoxvirus of family poxviridae. Various strains of capripoxvirus are responsible for the disease and these are antigenically and serologically indistinguishable from strains causing sheep pox and goat pox but distinct at the genetic level. LSD has a partially different geographical distribution from sheep and goat pox, suggesting that cattle strains of capripoxvirus do not infect and transmit between sheep and goats (OIE, 2010). The disease occurs in different ecological and climatic zones and extends its boundaries to different areas (Davies, 1991).

The lumpy skin disease virus in combination with sheep and goat pox viruses severely affects ruminants. Consequently it brought high economic pressure on subsistence of the poor farmers particularly pastoralists whose central economy relay on the production of livestock and the mixed farming system (Buller *et al*., 2005). It is transboundary disease, causes international ban on the trade of livestock and their products (www.merckbooks.com). LSD was spread to East Africa in 1957 in Kenya and the disease was extensively expanded to the rest of the region in subsequent years (Davies, 1991).

The quantification of the prevalence and incidence of the LSD is important to estimate the magnitude of economic damage, work load, costs and the required facilities to control the diseases (Pfeiffer, 2002).Risk factor assessments associated with the disease are also important for the mitigation of the occurrence of the outbreak. As a result disease incidences can be reduced and the optimum utilization of the animals would be high (Getachew *et al.*, 2011). The financial losses associated with occurrence of the disease could exert high economic burden to the households and to the national level. Such losses should be quantified to make decisions and apply control programs depending on the feasibility of the control programs (Morris, 1999).

Determination of seroprevalence of LSD has a time limitation for the presence of detectable antibodies in the serum for more than seven months of post infection. Serological tests such as virus neutralization are less sensitivity and time consuming to detect the low level antibody titres following the infection of the animals (Vorster, 2008; OIE, 2010). The use of the retrospective questionnaires survey are appropriate options, cheap and take less time to determine the prevalence of the disease based on the clinical features of the disease observed by herd owners. This is also important in areas where infrastructure was not fully facilitated to reach on times of outbreaks particularly in developing countries. It helps to provide adequate information to determine the herd prevalence, epidemiological risk factors and financial impact estimations of the disease and common tool to collect data in observational studies (Pfeiffer, 2002; Stevenson, 2005).

In Ethiopia very limited works has been done on this disease. So far few works have been reported on risk factors assessments, epidemiological aspects, seroprevalence and financial impacts in selected areas of the country Recently, a report on sero prevalence of disease using virus neutralization and indirect fluorescents antibody test indicated that the disease is widely distributed across the country and increases its impacts (Getachew *et al.*, 2010; Getachew *et al.*, 2011; Getachew *et al.*, 2012).

There were frequent outbreak reports of the disease though information available on the prevalence of the disease and its financial impacts in North Eastern part of Ethiopia is scarce.

Therefore, the results of the present study would provide baseline information on the prevalence and its associated risk factors as well as financial impacts due to the disease loss. Hence, the general objective of this study was to collect baseline information on the epidemiological aspect of the diseases and its financial impacts. The specific objectives of this study were;

- To determine observed herd level prevalence in the study areas
- To assess the risk factors associated with occurrence of the disease
- To assess the financial cost of the disease and financial benefit of the disease household level

2. LITRATURE REVIEW

2.1. Definition

Lumpy skin disease is infectious, eruptive and occasionally fatal disease of cattle. It is an acute to chronic viral disease characterized skin nodules in the skin and other body parts. The disease may be exacerbated by secondary bacterial complication (The Merck Veterinary Manual, 2011). It is caused by the genus capripox virus similar to that causing sheep pox and goat pox, and is transmitted mostly by biting arthropod vectors. The disease found in the Southern and Eastern Parts of Africa but recently, it spreads out to most parts of the continent and has the potential to extend and cross different ecological borders and cause severe economic losses (AUSVETPLAN, 2009 ; OIE, 2010).

2.2. Historical Perspectives

For the first time in 1929, skin disease with new clinical symptoms was occurred in Zambia. At that time it was considered as it was caused by either plant poisoning or an allergic response of insect bite (Weise, 1968; Bagla, 2005). After fourteen years, in October 1943, another outbreak of the disease was occurred in Botswana and named it provisionally as "Ngamiland cattle disease" as the case was occurred for the first time in Ngamiland. After two years, 1945 the disease spreads to Zimbabwe and South Africa where the disease named as the lumpy skin disease and the demonstration of the transmission of the infectious agent by the inoculation of the cattle with the suspension of the skin nodules was determined (Davies, 1991).

The disease was diagnosed in Kenya in 1957; Sudan in 1971; Chad and Niger in 1973; Nigeria in 1974 and Somalia in 1983 (Tuppuraninen, 2005). In 1988, the fist outbreak was occurred in Egypt in Ismailia and although control and eradication measures had been taken place the disease remains endemic in these areas (Ali *et al*., 1990). It was also observed clinically in Israel in herds of dairy farms in 1989 which was suggested as it was spread from the Egyptian outbreaks by the insect vectors carried by wind (Yeruham *et al*., 1995). The disease was primarily considered as an endemic disease to Africa and Middle East and other areas. According to the annual disease information released by OIE of the animal health situation worldwide, outbreak cases have reported from Bahrain in 1993/94,2002 Iran in 1996,2001 and other similar cases has been reported in United Arab Emerate, Kuwait and Oman (OIE, 2010).

2.3. Taxonomy and Characteristic of the Agent

Pox virus is among the largest and most complex DNA viruses which consist of several species of viruses which have both veterinary and medical importance. The virus is large enough to see under light microscope with virion size of 220-235x115-260nm. They can infect wide range of hosts and mainly affects animals (Murphy *et al.*, 1999). The poxviridae consists of two sub families; the Chordopoxvirinae and Entomopoxvirinae; the former one is viruses of the vertebrates including all the pox viruses infecting animals and the later one is the pox virus of insects. Chordopoxvirinae consists of eight genera and these have similar morphology with the exception of parapoxvirus which is not enveloped. The genera of the pox viruses and the disease they cause are outlined below (Carn, 1993; Carter *et al.*, 2005).

Table 1. Genus level subdivision of Poxviridae

Genera	Disease produced	Affected species
Orthopox virus	Vaccinia ,Variola ,Cowpox ,Feline, Horsepox ,Camelpox ,Buffalopox ,Monkeypox	Bovine,Feline,Equaine,Camel, Buffao,Monkey
Parapox virus	Bovine popular stomatitis,Pseudocow pox	Bovine
Capripox virus	Sheep pox, Goat pox virus and lumpy skin disease	Sheep, Goat & Cattle
Avipox virus	Fowl pox,Canary pox, Juncu pox	Poultry
Leporipox virus	Hare fibroma, Myoxomatosis and Rabbit fibroma virus	Rabbit, Hare
Molluscipox virus	Molluscicum contagiosum virus	Common disease of children
Suipoxvirus	Swine pox virus	Swine
Yata pox virus	Yaba & tana pox virus	Monkey

Source: Compiled from the international committee for the Taxonomy of Viruses (2002).

The genome of pox virus is double stranded DNA, monopartile and encodes over 100 genes. Virions are large, oval or brick shaped particle. There are over 100 poly peptides, which are arranged in a core with two lateral bodies, a membrane and an envelope which surrounds the virion (Traktman, 1996). The site of replication of the virus, unlike to the other viruses is in the cytoplasm. It is stable virus in PH of 6.6 to 8.6, ether sensitive and readily inactivated by sodium dodecylsulphate, formalin and chloroform (Murphy *et al.*, 1999). According to Carter *et al.* (2005) many of the poxviridae resist 50% glycerol and purified virus resists 100^0C dry heat and desiccated crusts retain infectivity for a year at room temperature.

Capripoxvirus is one of eight genera within the subfamily chordopoxvirinae of the family Poxviridae. The mature particles of the virus are smaller and elongated than the other pox viruses. They are extremely stable and survive in dry scabies and grazed pastures. It causes infectious febrile, occasionally fatal disease characterized by epithelial hyperplasia and formation of nodules in the skin. It occurs in Sub-Saharan countries and the Middle East, comprises of sheep pox, goat pox and lumpy skin disease viruses (Murphy *et al.,* 1999; Carter *et al.*, 2005; Babiuk *et al*., 2008).

The genus capripoxvirus differs from orthopoxvirus by having narrow vertebrate host ranges, only infect some ruminant species and have tropism to certain cell types (McFadden, 2005) and among the ruminant species which are susceptible to infection are sheep, goat and cattle (Ali *et al.*, 1990). Capri poxvirus infections are generally host specific and had specific geographic distributions. The species of the viruses are not possible to identify by serological and antigenic tests from one another. They are able to induce heterogous cross-protection and in some instances, experimentally cross-infection is also possible.

The clinical severity of the infection of the capripoxvirus depends on the strain of the virus and its dose as well as host susceptibility. Restriction fragment analysis and limited DNA sequence data supports a close relationship between capripoxviruses. The molecular basis of these viruses, host range restriction and virulence remains to be elucidated (Kitching *et al.*, 1989). According to the OIE (2010) lumpy skin disease virus has a partially adapted geographical distribution from sheep and goat pox virus at which lumpy the virus can’t cause clinical cases in sheep and goat.

2.4. Epidemiology

Lumpy skin disease is an important, economically devastating, notifiable disease which brought production loss in cattle due to generalized malaises and chronic debility (Tuppurainen and Oura, 2012). Good understanding of the epidemiological aspects of the disease such as the determinant factors related to agents, host and the environment in particular emphasis of the exposure assessments of the host to the environment and the association with the occurrence of the disease might aid in the prevention of the disease (Dohoo *et al*., 2003). The frequency of the morbidity and mortality of the disease, its geographic distribution and mode of transmission in large herds of cattle were observed to cause severe economic losses (Salib and Osman, 2006; Tuppurainen and Oura, 2012).

2.4.1. Risk Factors

Pathogen Risk Factors

LSDV is one of the species of capripoxviruses affecting cattle of different breeds and this virus is resistant to different chemical and physical agents (Murphy *et al.*, 1999). The virus can persist for about 33 days in necrotic skins and remain viable for at least 18 days in lesions in air-dried hides at ambient temperature. It can survive in a wet environment which can protect them from the rays of sun light (Weiss, 1968). The virus is very resistant in the environment and can remain viable for long periods on or off the animal host. They may persist for up to six months in a suitable environment, such as shaded animal pens. Capripoxviruses have lipid-containing envelopes and susceptible to a range of disinfectants containing detergents. They are susceptible to sunlight, but survive well at cold temperatures (Davies, 1981). The viruses are inactivated by heating for 1 hour at 55°C.

The virus is present in nasal, lachrymal and pharyngeal secretions, semen, milk and blood and it may remain in saliva for up to 11 days and in semen for 22 days (Barnard *et al.*, 1994). It can also persist for up to 33 days in necrotic tissue remaining at the site of a skin lesion. Material from skin lesions also contains infective virus when shed (Barnard *et al.,* 1994; Annandale, 2006). There is no evidence of the virus persisting in the meat of infected animals, but it might be isolated from the milk in the early stages of the fever (Davies, 1991). The virus may persist for months in lesions in cattle hides. LSD virus may persist for 6 months on fomites, including clothing and equipment but there is no evidence that virus can survive more than four days in the insect vectors.

The prototype strain of LSDV is the Nettling virus as reported by Alexander (1957). This is one of most strain mainly affects cattle. The virus can’t be distinguished by routine neutralization or conventional molecular tests from the other species of capripoxviruses. (Mathews, 1982). LSD virus is essentially identical with each other and with a Kenyan strain (O 240/KSGP) of sheep and goat pox virus (SGPV). The Kenyan group of SGPV strains showed differences when compared with ones from India, Iraq, and Nigeria. The strain variation and persistence of the virus for surviving in the environment is among the pathogen risk factors of LSDV (http://www.vet.uga.edu/vpp/gray_book/Handheld/lsd.htm ; Kitching, 1989).

Host Susceptibility

Lumpy skin disease is a disease of cattle and causes several disorders. Though all breeds and age group are susceptible, Bos *taurus* breeds are particularly more susceptible to clinical disease than zebu cattle. Among the *Bos taurus,* the fine-skinned Channel Island breeds develop more severe disease (OIE, 2010). Lactating cows appearing to be severely affected and result in a sharp drop in milk production because of high fever caused by the viral infection itself and secondary bacterial mastitis (Tuppurainen and Oura, 2012). Young animals are severely affected and the clinical symptoms are rapid to appear. Apart from these animals, few cases have been reported in Asian water buffalo (*Bubalus bubalis*). Clinical cases or antibodies have been reported in other species such as oryx, but may have been caused by closely related poxviruses (CFSPH, 2008). Generally the clinical severity of the disease depends on the susceptibility and immunological status of the host population.

Environmental Factors

Environmental determinants play a great role in the epidemiology of the lumpy skin disease. It had major impact on the agent, host and the vectors as well as the interaction between them. These predisposing factors have a great role in the maintenance of the arthropod vector and the transmission of the virus to susceptible animals (Thomas, 2002). These are herd risk factors that have an influence on the outbreak of the disease. Animals share the same grazing and watering points and unrestricted movement of animals across different borders following rainfall were some of the factors. Distribution of the disease in various agro climatic conditions, introduction of new animals to the herd and the presence water bodies are among the other risk factors that would facilitate the spread of outbreaks in various localities (Getachew *et al.*, 2011; Tuppurainen and Oura, 2012). The vectors which play a great role in the transmission of the virus are maintained in such environment associated with the coming of the wet season followed by autumn (Ali *et al*, 1990).

2.4.2. Geographical Distribution

Geographic distributions of LSDV, GPV and SPV is distinctly different and both SPV and GPV geographically ranged and restricted to Africa and Asia for the last fifty years extending from Africa to the north of equator (Kitching, 1989). LSD was originated from the Sub Sahara Africa countries in 1929 and spread to the north and south during the last seventy years. The geographic coverage of LSD has extended its range to include all countries in sub-Saharan Africa as well as Madagascar and it is endemic to most African countries and occurs in various ecological zones from the temperate areas to the dry semi arid and arid areas (Davies, 1991; Kitching and Carn, 2000).

2.4.3. Transmission

Though there was no clearly defined method of transmission of the lumpy skin disease, circumstantial evidences suggestions that the disease might be transmitted by biting insects (Weise, 1968). Later on, the virus was isolated from the arthropod vectors and the role of the vectors in transmission of the virus was experimentally confirmed. According to Carn and Kitching (1994), lumpy skin disease is endemic to most Sub-Saharan countries and the natural infection of cattle by the virus may be brought by different routes of infections.

Epidemiological evidence suggests, outbreaks of the diseases were highly associated with the prevalence of high insect vectors population and with upcoming of the rainy season. As Magori-cohen (2012) reported that the biting insects play the major role in the transmission of LSDV. The epidemics of LSD are associated with rainy seasons, river basins and ponds during which cattle grazed in and humid areas conducive to insect multiplication. These biting insects transmit the virus mechanically during their blood meals Chihota *et al.* (2001)

Currently it is widely accepted that LSDV is transmitted mainly by arthropod vectors. This vector-related transmission is apparently mechanical, rather than biological. This distinction is important because infectious organisms do not generally survive in vectors for long periods for multiplication or over-wintering in these insects. Study by Chihota *et al.* (2001) indicated that the virus can survive 2-6 days post feeding from the infected cattle and transfers this to the susceptible cattle by the female mosquito, *Aedes egypti* during experimental infection. The virus can survive only for about average four days and this can't permit for the recurrence of the disease in the coming season. It was thought that infected vectors can transmit the disease some distance kilometers from the foci of infection as the occurrence of outbreak in 1989 in Israel following aerial movement of infected insect vectors from Egypt (Yeruham *et al.*, 1995).

Mosquitoes and other flies such tabanids, Culicoides, biting midges and *Glossina* species like tsetse fly are among the other arthropod vectors that play a great role in the transmission of the virus. The participation of these flies in the spread of LSDV have been confirmed by isolation of the virus from the stable flies feed on infected cattle and this indicated that these flies are efficient vectors of capripoxviruses (Bruce *et al*., 2000). Flies, including the housefly, bush fly and blowflies are also very commonly associated with infected cattle possible to siphon off infected lachrymal, nasal or other secretions and transfer the virus to another susceptible animal. Vermin, predators and wild birds might also act as mechanical carriers of the virus (Kitching and Mellor, 1986; AUSVETPLAN, 2009).

The outbreaks of the lumpy skin disease are highly associated with the seasonal peak of mechanical vectors in wet and warm weather conditions in Ethiopia (Getachew *et al*., 2010). Recently Tuppurinen *et al.* (2010) showed the molecular evidence of the potential viral transmission by hard ticks. The virus could be transmitted through transstadial and transovarian in *Boophilus.decoloratus* and mechanical transmission by *Repicephalus appendiculatus* and *Ambyloma hebraeum*.

Transmission of LSD is also possible by sharing of the same feeding and watering troughs which may be contaminated by the viruses in the saliva of the infected animals or ingestion of the already contaminated food or by iatrogenic agents (Haig, 1957) and the suckling calves may be infected through the infected milk (Thomas,2002). Transmission by contact in the absence of the arthropod vectors was not efficient (Carn and Kitching, 1995). A study in Ethiopia also showed that communal grazing and watering points were found to be associated with the occurrence of LSD (Getachew *et al*., 2010); introduction of new animals to a herd had a strong association with an increased risk of disease in the herd.

Excretion of the LSDV in semen was detecting using PCR from the experimentally challenged bulls by Osuagwuh (2006). Great risks are imposed that semen or the movement of semen from countries where the disease is endemic can transmit the disease (Irons *et al.*, 2005) but no standard procedures were present to detect the presence of LSDV in semen. Information was unavailable on transmission of LSD virus via semen or embryos. The virus excretes in the semen for up to 22 days in clinically affected bulls and about 12 days in sub clinically affected bulls (Weiss, 1968). There were also assumptions that the virus also secreted in vaginal secretions. The extremely resistant nature of the virus to the environment would therefore make venereal transmission very likely (Committee on Managing Global Genetic Resources, 1993). Due to insufficient information, the International Embryo Transfer Society has not classified LSD virus regarding the likelihood of its transmission via embryos.

Experimentally, virus inoculation can cause generalized infection following parental inoculation but it was observed to cause mild local lesions by intra dermal inoculations. Generally transmission of the virus by contact is inefficient and field evidence reported that the disease is not contagious as reported by Tuppurainen in (2005). Experimentally, transmission has occurred between cattle in adjacent insect proof enclosures that share the same water trough. Nasal and laryngeal secretions, semen and blood could potentially play some part in the transmission of the virus, but virtually in all outbreaks the virus appears to be propagated continuously from infected cattle to arthropod and then to the cattle that forms cycle.

Virus can be transmitted by the animal products such as milk, fomites such as equipments and clothing as well as personnel. Though most infection is thought to be the result of insect transmission, field observations have demonstrated that the spread of the virus from farm to farm and district to district might be due to the absence of complete restriction of all animal movements (Tuppurainen, 2005; AUSVETPLAN, 2009). The main factors that could influence the transmission of the disease was, prevalence of insect vectors which affect the rate of transmission of the virus and would be sharply reduced in the transmission of LSD after cold weather and frosts, which are associated with reduced insect vector populations .

The movement of infected stock, road and rail transport could play an important role in rapidly spreading the disease over larger areas (Kitching and Mellor, 1986). As indicated in the Australian veterinary emergency plan for lumpy skin disease (2009), the risk of introduction of the disease virus to one country or to the new areas may be by the movement of these infected animals or infected premises. The presence of the wild life reservoirs has the potential for the spread of the virus. Though the virus has narrow host rang, limited information are available about the natural infection of the virus to the wild buffalos but according to Ali *et al.*(1990), there were five water buffalos during the outbreak in Egypt 1988 outbreak in Egypt.

Later in the second outbreak in 2006, the virus was detected by PCR from the tissue samples and their milk and confirmed their susceptibility to the virus. Circumstantial evidence indicated that the virus can also observed infecting the Arabian female Oryx and the disease was clinically observed in experimentally inoculated giraffe and impala (Young *et al*., 1970; Greth *et al*., 1992). Capripoxvirus was detected using electron microscopy from the skin nodules of the oryx, and raised antibody levels against capripoxvirus were detected in paired serum samples tested using a neutralization test.

2.4. Economic Impact

Capri pox viruses are becoming an emerging worldwide threat to sheep, goats and cattle (Babiuk *et al.*, 2008). Lumpy skin disease is one of the economically significant diseases in Africa and the Middle East countries that cause severe production loss in cattle. The world organization for animal health (OIE) categorizes the disease as notifiable diseases because of its severe economic losses. The economic importance of the disease was mainly due to having high morbidity rate rather than mortality (Tuppurainen and Oura, 2012). The financial implication of these losses is greatly significant to the herd owners, consumers and the industrial sectors which can process the livestock products and by products.

In intensive farming of cattle, the direct and indirect production losses caused by LSD were estimated to be as high as 45-60% (Tuppurainen and Oura, 2012). It was reflected that the severity of the disease was much more in developing countries where the poorest small scale farmers was found. Reports from Ethiopia indicated that the financial loss estimated based on milk, beef, draught power, mortality, treatment and vaccination costs in individual head of local zebu were lost 6.43 USD from beef, milk and draft power output and for the Holstein Friesian 58 USD (Getachew *et al.*, 2010).

The disease mainly affects cattle with subsequent effects on production through the morbidity and reduced productivity (CFSPH, 2008). The major consequences of the disease are retarded genetic improvement, limits the ability of the animal to work, draught power and traction loss, abortion in pregnant cows, marked reduction of milk yield during the active case of the disease, sterility and infertility in both sexes of cattle, permanent damage to the hide and chronic debility in beef cattle. Control of the disease with special emphasis to endemic areas is an important way to reduce the losses and increase the incomes of cattle owners (Tuppurainen, 2005; OIE, 2010).

Control costs associated with the disease might depend on the type of program to carry out. Israel and Egypt tried to eradicate the disease by slaughter and mass vaccination. The compensation for the compulsory slaughter of infected and in contact animals would impose some hardship, for loss of valuable genetic potentials and lack of finance for compensation. Prevention of restocking until after a possibly lengthy prescribed period had elapsed would exacerbate serious cash flow problems on infected premises and in contact premises (Thomas, 2002).

Movement restrictions within the restricted area and area control would cause loss of market opportunities and associated financial losses to affected properties in the area and to support industries such as stock transport (Tuppuraine, 2005). Therefore, the disease must be major foci of activity for its control and the economic implication of the disease must be established and return to the investment for its control. The impact of the disease is beyond a single farm unlike to some of the parasitic diseases. Outbreaks of the disease in one herd impose risk to the neighbors in the production system where there is poor control of cattle movement. This significant economic impact of the disease is mainly due to the morbidity and to lesser extent because of mortality (Tuppurainen and Oura, 2012).

Morbidity is the proportion of affected animals in a given population which includes both the prevalence and incidence of the disease. Both measure the risk that susceptible animals in a population have contracting the disease (Dohoo *et al.*, 2003). Morbidity rate of LSD vary highly between herds and different climatic conditions. Prevalence is defined as the number of infections, both old and new cases, in a given cattle population at a given time but incidence is the number of new cases that occur in a known population over specified time period and both express the infected cattle in relation to the population at risk (Getachew *et al.*, 2011).

The morbidity and mortality rates for LSD vary greatly in different endemic areas depending on the severity of the strain, prevalence of insect vectors and susceptibility of the host (Getachew *et al.*, 2010). An outbreak in a previously free country could be expected to result in a high morbidity rate. If LSD became endemic, continuing economic loss and poor productivity would occur due to stock losses, reduced production in the cattle industries and the cost of preventative vaccination. Permanent loss of some markets would also be expected, with associated downturn in the rural economy and increased rural unemployment (Tuppurainen and Oura, 2012).

Overall, LSD is considered as a disease of high economic pressure because of its ability to compromise food security through protein loss, draft power, reduced output of the animal production, increase the production costs due to the increased costs of the disease control, disrupt livestock and their product trade, result of the reduced milk yield, weight loss, abortion, infertility in cows, mastitis and infertility in lactating cows, infertility in bulls (Weiss, 1968; Kumar, 2009).

Permanent damage to the skin and hide greatly affect the leather industry. It causes ban on the international trade of the livestock and cause prolongs economic loss as it became endemic and brought serious stock loss. The cost of preventive vaccinations ,eradication and movement restrictions within the restricted area and control area would cause loss of market opportunities and associated financial losses to unaffected properties in the area and to support industries such as stock transport (AUSVETPLAN, 2009; Getachew *et al.*, 2010).

2.4.1. Livestock production in Ethiopian Economy

About 85 % of the Ethiopian population was engaged in agriculture as their primary occupation and 90% of these rural communities use animals for different purposes. About 80% of the Ethiopian farmers use animals for traction purpose and among these the draft power accounts for about 60% of the value of the products derived from the cattle because of its substantial role in food production. One of the primary purposes of keeping cattle in highland areas is draft power though the milk and other products obtained provide valuable supplementation to the household (Azage, 1998).

In these areas 51% of the animals are draught animals under traditional mixed farming system. Those draught animals are estimated to work an average of two months or sixty working days per year in case of Ethiopia as compared to 10 months in India based on the length of cropping season and religious holidays (http://tinyurl.com/IGADLivelihoods). According to CSA (2011), among the 53.4 million cattle in case of Ethiopia, approximately 80% of the cattle population found in high land areas which are over 40% the countries land. The remaining cattle population; 20% is located in lowlands areas which were characterized by low rain fall and cover 60 % the land area.

Majority of the farmers (78%) operate traditional mixed crop livestock production systems and the remaining engages exclusively in either crop production or livestock production (http://tinyurl.com/PastoralTrade). In addition to the direct and indirect importance to the farmers, livestock contributes a lot to the Ethiopians economy as source of foreign currency from the export of live animals, packed meat from beef and the provision of skin and hide. In general the livestock sector provides about 45% of the agricultural production (http://tinyurl.com/IGADLivelihoods).

In lowland areas of the Ethiopia, most of the society is pastoralists and to a lesser extent agro pastoralists which mainly depend on the livestock and their products especially milk production. The milk production from the Ethiopian local zebu are vary from area to areas which might be due to the genetic potential and availability of feed resource but the average net production of milk set by CSA (2011) were 1.857 liter per day. In case of the selected districts of Afar Region, the average production of milk was 2.823 liter per day but in case of Southern Tigray the average production was found to be 1.194, at both regions for the average lactation of six months. With these close ties of livestock and the people, there are several constraints which constrain the production potential of the livestock. Diseases are one of the main factors which hinder the production potential. The present study focuses on one of the diseases , LSD which has great impact on milk, beef and draught output production, infertility, abortion, damage to hide and skin and other socioeconomic consequences.

2.4.2. Principles of Partial Budget Analysis

In the modern animal production system, due to the influential role of management and the progression process of different diseases, animal health economics play central role to make right decisions by considering all opportunities and constraints. Partial budget analysis is one the econometric analysis tools which aid in the decision making process for implementation of projects (Putt *et al.*, 1988). It assesses before and after implementation of projects in the farms and national level analysis for decision making by policy makers for intervention of animal health by considering the benefits obtained from the control of the disease and costs associated with the control techniques. It is calculated on annual basis using budgets to guide short term decisions or long term projects using cost benefit analysis. LSD is one of the diseases of cattle which exert high economic pressure or burden on the herd owners and as whole at national level (Marsh, 1999; FAO, 2011).

In the present study, the principles aids in the financial evaluation of the benefits obtained from the control of LSD in the sedentary and non- sedentary private peasant holding of the traditional mixed crop livestock farming system and the pastoral and agro pastoral husbandry systems as well as the costs incurred for the control of the disease. The method assesses the change in costs and benefits resulting from small changes such as the use of new technologies on the livestock farms. It compares the marginal changes of the costs and benefits which result from undertaking of the project (Getachew *et al.*, 2011; FAO, 2011).

The disease affects different sectors of production and various segments of the society involved in these productions such as the producers, consumers, associated agribusiness, government and the society as whole. From this if the benefits exceeded the costs, then the change will be advantageous for the system and to adopt the technology, it must be determined by the marginal rate of return obtained from the change. Marginal return rate measures the increase in the net benefit divided by the total cost that varies only by implementing the planned vaccination. In other words for the project to be accepted the benefit cost ratio should be greater than one and this is a useful technique for the ranking of different projects of different size (Abbot and Makeham, 1979 ; Morris, 1999).

2.5. Pathologenesis

The infection of LSD can be acquired through natural or experimental infection and experimental intravenous transmission was efficient way. The disease developed by the infectious LSDV is systemic and accompanied with febrile reaction (Vorster, 2008). The mechanism by which LSDV was observed to cause skin lesions was due the virus replication in specific cells such as pericytes and endothelial cells of the lymphatic and blood vessels walls. The LSD is generalized disease and epitheliotrophic and cause localized and systemic reaction. This result in vasculitis and lymphadenitis and in some severe cases thrombosis and other symptoms were observed (Radostitis *et al*., 2006; Merck Veterinary manual, 2011).

Nodules of the lumpy skin disease may be found on the subcutaneous tissues, muscle fascia and musculature, which are grey-pink with caseous necrotic cores. The gross lesions of LSD were according to the description by the Haig (1957) and Barnard (1994) which are congested, haemorrghic, edematous and necrotic and involve all layers of the skin, the epidermis, dermis, subcutaneous and the underlying musculature. Circumscribed necrotic lesions may appear in the muzzle, mucous membrane of the mouth, respiratory tract, trachea, vulva and prepuce which may ulcerate. Histopathological sections of the early skin lesions of epidermis show an epitheloid cells, lymphocytes, macrophages, plasma cells and fibroblast proliferation appear in the later stages and if secondary infection occurs ,necrosis, polymorph nuclear and red cells seen. Typical eosinophilic, intracytoplasmic pox inclusion bodies may be seen in the cells of the epithelioid, hair follicles and cells of muscles and skin glands (Bagla, 2005; AUSVETPLAN, 2009).

2.6. Clinical Signs

Lumpy skin disease is an acute to in apparent cattle disease caused by LSDV. It is characterized by fever, nodule in the skin, mucous membrane and internal organs and swelling of the superficial lymph nodes (OIE, 2010; Tuppurinen and Oura, 2012). Incubation period of lumpy skin disease can vary under field condition and experimental conditions, which can vary from 5 days in experimentally inoculated animals and 2–4 weeks in naturally infected animals (Wood, 1990; Barnard *et al.*, 1994; OIE, 2010) gives a maximum incubation period, for regulatory purposes, of 28 days.

The course of lumpy skin disease may be acute, sub acute and chronic and the infection of LSDV may occur both experimentally and under natural condition. The virus causes from in apparent infection to severe clinical symptoms and those animals which develop clinical disease may have a biphasic febrile reaction. Some of the visible clinical signs are; fever of 40-41.5^{o}C which may last 6-72 hours, lachyrimation , increased nasal and pharyngeal secretion ,loss of appetite, reduced milk production ,some depression and movement reluctance. The severity of the clinical signs depends on the strain of the capripoxvirus and breed of the host cattle and in case of experimental infection route of transmission and dose of the virus also has determinant factor (Carn and Kitching, 1995; LSD contingency plan for the Netherland, 2002; OIE, 2010).

According to the description by Davies (1991) infection of cattle under field condition may develop generalized skin lesions after one to two days of febrile, nodular cutaneous lesions appear which may cover the whole body ranging from a few to multiple nodules but in majority of the cases, the initial evidences of symptoms are lachyrimation and fever but some cases are non-febrile. Prescapular and precrural lymph nodes are some of the superficial lymph nodes which commonly seen during the clinical manifestation of the disease (Tuppurinen and Oura, 2012). The most common sites are the head and neck, perineum, genitalia, limb and udder; involve the skin, cutaneous tissues and some time the underlying part of the muscle.

The diameter of the nodular lesion may be up to 1-7 cm diameter appears as round, circumscribed areas of the erected hair. In severe cases, ulcerative lesions may develop in the mucous membrane of the mouth, trachea, and larynx and esophagus. Such ulcerative lesion also develops in the conjunctiva, muzzle, nostrils and small nodules may resolve spontaneously without any consequence. Secondary bacterial complication and infestation of fly worms may be occurred (CFSPH, 2008). As stated by Barnard (1994), nasal discharge and salivation may be developed in to mucoid or mucopurulent, the lachyrimation to conjunctivitis, the superficial lymph nodes markedly enlarged and the inflammatory and edematous lesions in the limbs, brisket and genitalia may develop and the skin lesion may be necrotic and the ulcerative lesions may become fibrotic.

Some of the scabbed lesion remains there and the other sloughed leaving a hole full of skin thickness which becomes infected by pus-forming bacteria and large areas of skin may slough. Lesions in the skin, subcutaneous tissue, and muscles of the limbs, together with the severe skin inflammation caused by secondary infection of lesions, greatly reduce mobility as indicated by Murphy *et al.* (1999). Rapid deterioration in body condition results and animals that recover may remain in extremely poor condition for up to 6 months. Pneumonia is a common bacterial complication and usually fatal disease and absence of estrus cycle and abortion are the common consequences observed in female animals and painful genitalia may prevent the bulls from serving (AUSVETPLAN, 2009).

2.7. Diagnosis

According to Carn (1995) LSD would be presumptively diagnosed based on the case history and apparent clinical findings of generalized characteristic skin nodules, swelling of the superficial lymph nodes, fever, lachrimation and others. Tentative diagnosis of LSD for the in apparent and mild disease was difficult to diagnose (OIE, 2010). Rapid laboratory tests are needed to confirm the disease. Laboratory test of the LSD can be made by the identification of the agent, routine histopathological examination and immune histological staining. The agent may be isolated on cell culture of different origin and conventional serological tests may be also used for the detection of virus antibodies. Recently developed molecular techniques detect the virus nucleic acid or DNA such as the polymerase chain reactions (Tuppurainen, 2005). The principle of these diagnostic techniques and tests will be summarized shortly in the following paragraphs.

2.7.1. Isolation of the Virus

Specimens for virus isolation will be collected by biopsy or at post-mortem from skin nodules, lung lesions or lymph nodes within the first week of the occurrence of clinical signs, before the development of neutralizing antibodies. When the disease occurs for the first time, specimens must be taken from the skin scrapies, biopsies, blood, semen and others which serve for virus isolation, histopathology and electron microscope (House, 1990; OIE, 2010). Though the growth of the LSDV is slow and tedious it will grow in bovine, caprine and ovine cell cultures but the best growth will be seen in cells of lamb tests (Davies, 1991; CFSPH, 2008). Primary cell cultures are bovine skin dermis and equine lung cells, but the growth of such viruses is slow and requires several passages. In case of the biopsy samples tissue cultures may be contaminated by bacteria and fungi particularly those require prolonged incubations (Tuppurainen, 2005).

2.7.2. Serological Tests

Serological tests are used for the retrospective confirmation of lumpy skin disease but they are much more time consuming to be used as primary diagnostic methods and limited presence of detectable antibodies in the serum (Vorster, 2008). These tests have limited importance because of the low response of the antibody but still widely used as gold standard methods for the detection of capripoxviral antigen and antibody. All capripoxviruses share a common major antigen for neutralizing antibodies and it is not possible to distinguish strains of capripox virus from the cattle, sheep and goats by serological tests. Among the recently developed serological tests that can detect antibodies in sera is the virus neutralization test (VNT), Agar gel immune diffusion (IAGID) and indirect fluorescent antibody test (IFAT). Serum neutralization is the test of choice for serosurveillance, but it has low sensitivity. There may be problems of detecting low titres in individual animals, but it is a reasonable herd test. An enzyme-linked immunosorbent assay (ELISA) is highly developed serological technique for the detection of the recombinant antigens (AUSVET PLAN, 2009; OIE, 2010).

2.7.3. Polymerase chain reaction (PCR)

The recently developed molecular technique, polymerase chain reaction (PCR) changes the biological science as it revolutionized the detection and characterization of microorganisms, enables the minute DNA of the organism to replicate very rapidly and makes easy to detect ,study and use for any medical purpose. Conventional gel based PCR is more time and labor consuming and could not differentiate between the species of the capripox viruses but the real- time PCR will be faster than the former one (Valones *et al*., 2009 ; Tuppurinen and Oura,2011). With this principle, the technique is used for the rapid diagnosis of the causative agent of the LSD. It is simple, fast and sensitive technique to detect capripoxvirus genome in EDTA blood, biopsy, and semen or tissue culture samples. However, it does not allow differentiation between LSD and sheep and goat pox viruses as they are closely related

(Ireland and Binepal, 1998). PCR for the diagnosis of LSD is with a greater sensitivity and good specificity and it is most appropriate technique (Kholy *et al.*, 2008; OIE, 2010).

2.8. Differential Diagnosis

There are several skin problems which may confuse with appearance of the lumpy skin disease in the field conditions. Bovine herpes mammillitis is caused by Bovid Herpesvirus-2 and characterized by the lesions that are superficial (involving only the epidermis) and occur predominantly on the cooler parts of the body such as teats and muzzle. Dermatophillosis is characterized by the superficial lesions, often moist (Merck veterinary Manual, 2011). It appears as a crust and scabs and accumulation of the keratinized material and lesions are common in the skin of the neck, auxiliary region, inguinal region, and perineum (Radostitis *et al*., 2006). Ringworm is one of the fungal disease in cattle with a grayish, raised, plaque like lesion. Hypoderma bovis infection is the parasitic fly larvae of this parasite that have a predilection site to migrate to the dorsal skin of the back. Demodicosis is mengemite parasitic disease what forms nodules (http://www.vet.uga.edu/vpp/gray_book/Handheld/lsd.htm).

2.9. Prevention and Control

2.9.1. Vaccination in endemic areas

Immunity acquired from natural infection of the disease might be lifelong and vaccination has been successfully used, LSD could be kept under control by vaccination of the cattle every year (Thomas, 2002). All strains of capripoxvirus examined so far, whether of bovine, ovine or caprine origin, share a major neutralizing site, so that animals that have recovered from infection with one of the strains are resistant to infection with any other strain. Consequently, it is possible to protect cattle against LSD using strains of capripoxvirus derived from either of the sheep or goats as used in Egypt by the Romanian sheep pox strain (OIE, 2010).

Live, attenuated vaccines against LSD are commercially available. These have antigenic homology and there is cross protection among them. Local strain of Kenyan sheep and goat pox virus has been shown to effectively immunize sheep, goats and cattle against infection with capripoxvirus with a remarkable success. The next one is attenuated South African LSD virus (Neethling strain) vaccine derived from cattle, freeze dried product is also available (OIE, 2010). In countries where LSD is endemic the vaccination against this infection was successfully used by vaccinating the animals every year.

LSDV has been used as a recombinant capri poxvirus, combined with rinderpest or rabies virus and cappripox virus is an excellent vector for the recombinant vaccines because of its narrow host range even it is a novel candidate vector for HIV-1 which is the serious public health, based on the replication deficient, as it will not complete its cycle in non-ruminant hosts (Shen *et al.*, 2011).

2.9.2. Vaccination in new areas

Risks of introduction of the disease in to the new areas are by the introduction of infected animals and contaminated materials (Davies, 1991; Kitching, 1995).If the occurrence of LSD is reported or confirmed in new areas, before the spread of the disease to other areas extensively, quarantine of the area, slaughtering of the diseased and in contact animals and contacted equipments must be cleaned and disinfected (Davies, 1991; Netherland contingency plan of LSD, 2002; AUSVETPLAN, 2009). Ring vaccination of cattle within the foci of infection with a radius of 25-50 Km , quarantine and animal movement should be restricted to eradicate the disease from the area, but if the area coverage of the disease is large, the most convenient techniques for the control of the disease is mass vaccination of the cattle. These two techniques, slaughter and vaccination were practiced in Israel and Egypt since the first outbreak of the disease occurred and it was effective for the time being (Yeruham *et al.*, 1995).

2.9.3. Other control techniques

For countries free of the disease, the introduction of the disease can be prevented by restriction of the importation of the animals and their products but in those nations which experience the infection can limit the spread of the lumpy skin disease by restriction of the animal movement from one place to another, quarantine, keeping of sick animals well apart from the rest of the herd and must not share drinking or feeding troughs by making awareness creation of the farmers (Thomas, 2002).

Animals older than six months must be vaccinated against lumpy skin disease during spring. It is safe to vaccinate pregnant cows. All animals must be vaccinated once a year. When vaccinating the animals during a disease outbreak, it is important to use one needle per animal so that the virus is not spread from sick to healthy animals. Professional help and recommendation on vaccines must be carefully followed and practiced. Antibiotics also given to prevent the secondary bacterial complication as the defense mechanism of the body weakened which can prolong the complete recovery of the diseased animals (CSFPH, 2008).

2.10. Status of Lumpy Skin Disease in Ethiopia

The direction of the expansion of the outbreak of lumpy skin disease was southward of Sub Sahara starting from Zambia to Botswana and South Africa (OIE, 2010). The disease was introduced in to East Africa in 1957 in Kenya and Sudan in 1972 but the outbreak of the disease in case of Ethiopia was reported between the time period of 1981 and 1986 (OIE,2010). Following its appearance from that time, epidemics of disease was spread extensively and covers large areas of the nation, from the north, central to the southern part of the country. Studies based on the clinical observation of the disease were conducted in some regions and different animal level prevalence was reported (Asegid, 1991; Regasa, 2003).
Some data of the reported outbreaks of the disease recorded by Ethiopian National Veterinary Institute (NVI) were obtained. These outbreaks were reported from different part of the country starting from 2007-2011 and mainly consist of the number of outbreaks observed for the five consecutive years in various areas as indicated in table-2.

Cross sectional study based on questionnaire survey was done on observed cases of LSD and associated risk factors Getachew *et al*. (2010). In addition this by the same author epidemiological aspects and financial impacts of the disease was conducted in selected areas of the country Getachew *et al*. (2010). The study also assess the distribution of the disease in three agro climatic conditions of lowland, highland and midlands areas by Getachew *et al*. Recently, sero prevalence of the disease in these three different agro ecology was also was also conducted by the same author in Ethiopia (Getachew *et al*. ,2012).

Table 2. Reported outbreaks & affected populations of LSD in various Parts of Country (Source : National Veterinary Institute ,2007-2011).

Region	2007	2008	2009	2010	2011	Total
Addis Ababa	0	0	3	7	1	11
Afar	0	0	3	2	2	7
Amhara	92	68	35	40	22	257
Ben. gumuz	3	0	0	0	5	8
Gambela	0	0	0	1	9	10
Oromia	95	154	219	268	160	896
SNNP	18	18	14	32	17	99
Somali	0	0	3	9	4	16
Tigray	7	8	2	18	13	48
Grand Total	215	248	276	375	233	1347
Regions	Active outbreak	Number of Cases	Death	Animals at Risk	Control Vaccination	Prophylactic Vaccination
Addis Ababa	11	190	5	19600	2867	1710
Afar	2	35	0	615	0	0
Amhara	365	11332	765	2414697	866518	179366
Ben. gumuz	10	459	29	37043	0	0
Gambela	10	553	77	95955	1765	2545
Oromia	1066	34280	1741	9839574	2605445	603412
SNNP	123	7281	970	1200919	252917	100938
Somali	28	3608	410	571638	0	110000
Tigray	61	4438	375	591790	128206	135708
Total	1676	62176	4372	14771831	3857718	1133679

3. MATERIALS AND METHODS

3.1. Description of the Study Areas

The study was conducted in the north eastern part of Ethiopia, in Afar and Tigray region. Afar region is one of the pastoral areas in Ethiopia located in the North eastern part of the country. It has five administrative zones which are further divided in to 29 districts. It has two international borders with Eritrea and Djibouti and four national borders with Tigray, Amhara, Oromiya and Somali regional states (Piguet, 2001). The region is geographically located at 8°40˙ to 14°47˙ North latitude and 39° 51˙ to 42° 23˙ East longitude. The Altitude ranges from 150 meter below sea level to 1000 meter above sea level.

The region mainly represents pastoral (90%) and agro pastoral (10%) production system covering areas of 85,410 Km^2 with estimated human population of 1.3 million. The mean annual rainfall is 561mm in the western edge of the escarpment and 225.3mm in the lava plain areas. Disruptions on the performance of the rain season will have an impact on the availability of pasture and water. The mean minimum and maximum annual temperature ranges between 18^0Cand 35^0C (Piguet, 2001; CSA, 2008). Approximate estimation of the livestock population in the area is 2,318,220 cattle, 2,499,640 heads of sheep, 4,444,290 heads of goats,859,580 camels and 16,967 donkeys (CSA, 2008; Afar National regional state, 2010). Seasonal movements of the herds are routinely practiced in the region mainly to upper Awash, Amhara and Tigray region in search of pasture and water (Philpott *et al*., 2005).

From five zones of Afar, two zones (Zone-1 and Zone-4) included in the study. From Each zone one district was selected for the study (Asiyta and Yallo). Asiyta is located 11°34′N 41°26′E and an elevation of 300 meters asl. It is located at 70 km south East of Semera. The area has humid, moist climate with short bushy vegetations such as prosopis. Awash River is the main River in the area on which nomads depends on for agro pastoral activity, cultivates some sorts of crop like maize and cottons. Yallo district was located in the western part of Afar region sharing borders with Alamata and Raya Azebo. The society is purely pastoralist

and livestock production is the central economy of the pastoralists. The livestock movement to Alamata and Raya Azebo usually undergoing during dry season (Philpott *et al*., 2005).
Tigray region was the other study area located in the most northern part of Ethiopia and bordering with Eritrea in the north, Sudan in the west, Afar in the east and Amhara in the southwest. The region extends from 120° 13' to 140° 54' N and from 36° 27' to 40° 18' E. The region has five Administrative Zones: Western, Northwestern, Central, Eastern and Southern zones. This study was carried out in Southern zone of the regional state, which is located at 660 km north of Addis Ababa and 120 km south of Mekele. Tigray region has a 3,630,957 heads of cattle population of these 699,559 cattle population are found in the study zone CSA (2011).

The study zone is geographically located 12^o 15'and 13^o 41' North latitude and 38^o 59'and 39^o 54'East longitude, constituting an area of 9446km^2. It shares common border with south eastern Tigray zone in the north, Amhara regional state from the south and west, Afar Regional state from the east. Five districts are available in the zone and two of them were included as study sites: Ofla and Alamata (Tigray livelihood report, 2005).These districts share similar farming system but in different agro ecological locations.

Ofla is from the highland area surrounded by chain of hills and one natural lake, Hashenge. There is high livestock potential in the area and during summer and winter season they move their animals to the lowland areas depending on the availability of rain particularly farmers with large herds. Alamata is located in 12^{o}15'N latitude and 39^{o}35' E longitude and that share border with Amahra and Afar regional states and cross border movement of livestock from the two regions were intermingle or share the same grazing and watering points. The district composed of mainly lowland and some kebeles are from the high land areas (Tigray livelihood report, 2005; CSA, 2007; REST, 2007).

Tigray ,Afar,Amhara regional states and their corresponding districts share many characters with each other such as the inter regional border movement of animals, market activity . The study districts from Tigray region possess similar breed of cattle population, camel and other livestock with Afar (Philpott *et al*., 2005). Disease transmission from one place to another could occur during this time and some of the main disease hazards such as pasteurellosis, blackleg, anthrax, foot and mouth disease (FMD) and lump skin diseases (LSD) are very common in these areas.

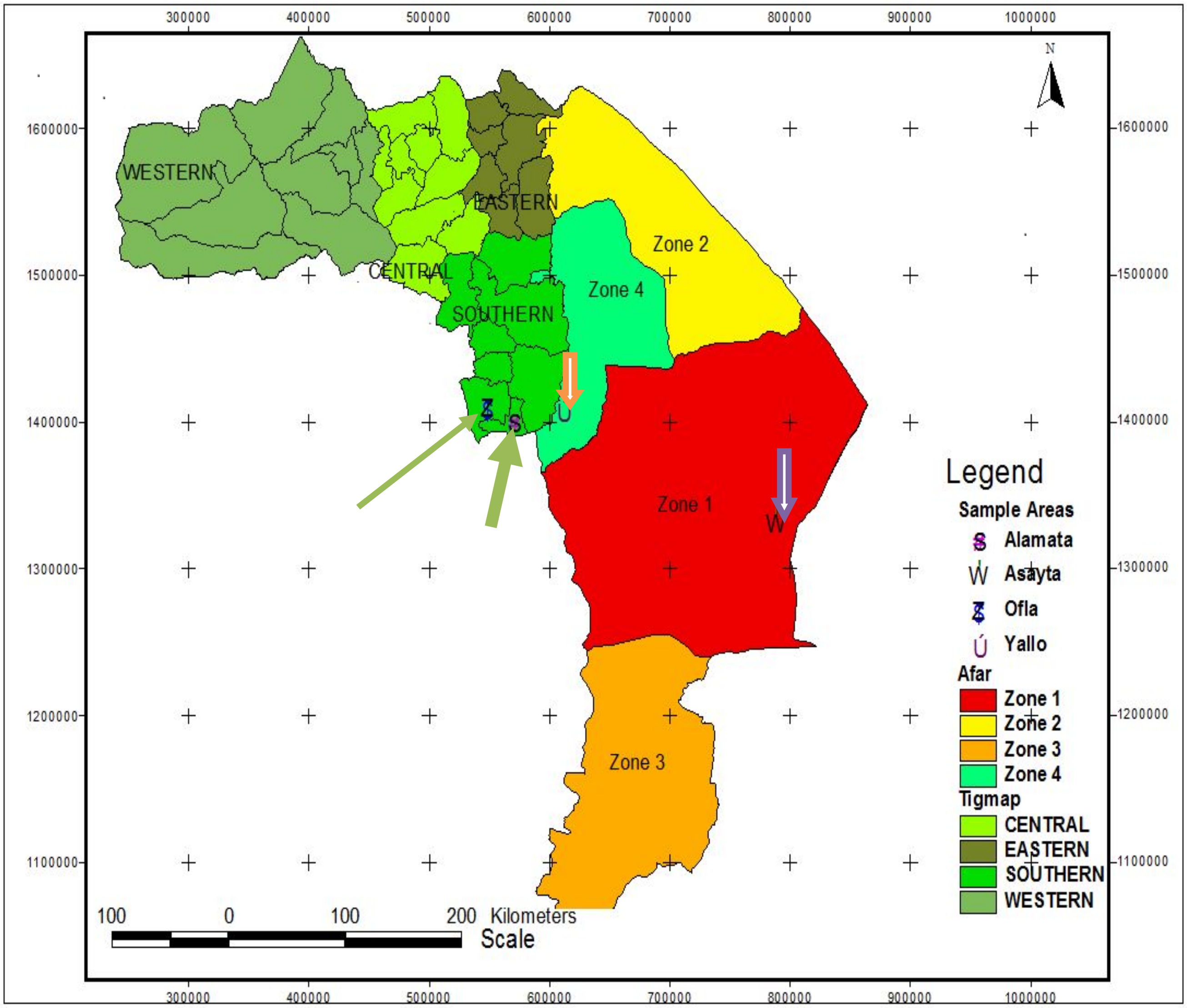

Figure 1. Geographic location of the Study area. **Source: Ethio GIS**

3.2. Study Population and Husbandry System

The target study population was comprised of the cattle of all ages in selected districts of Afar and Tigray regional States. These cattle population are under managemental conditions of communal grazing and watering points. Depending on the rainy season, animals move from one place to another in search of pasture and water . Some of the herds from the mixed farming system feed on crop residues during the dry season and some cattle from peri urban may practice separate grazing. These cattle were found in various agro ecological, climatic conditions, may be with or without the history of vaccination, in different physiological state and husbandry practice. The target cattle population listed below was obtained from the respective districts and a total of 299,959 heads of cattle from the four selected districts with Asiyta (80130), Yallo (36,113), Alamata (110102) and Ofla (733614) were recorded.

3.3. Study Design and Methodology

3.3.1. Study Design

Cross sectional study was carried out to collect epidemiological data for the assessment of the risk factors and financial impacts based on the questionnaire survey. The study was conducted between October 2011 to February 2012 in fifteen peasant associations distributed over four districts of Afar and Tigray. The study approach was based on the observation of the clinical signs of LSD by the herd owners for the last two years. The questionnaires were administered by face to face interview to the herd owners using the local language. The questionnaire for Afar study site was undertaken using translators form the district veterinarians and the rest sites were covered by the researcher using the local language. Herd owners were asked to explain the symptoms of the disease and cross checked by enquiring some questions. The time period for the risk factor assessment was within the time period of two years from October 2009 to October 2011. This two year interval was done to avoid the recall biases of the herd owners.

In the same study population, district and peasant association, a financial impact was assessed using questionnaire survey within time horizon of one year production cycle from December 2010 up to November 2011 in the study districts. One year production cycle was used to calculate the annual loss associated with the disease because of the fear of memory loss to individual animals' history. Partial budget analysis was used for the analysis of the benefit cost analysis of the disease control. The data obtained from the survey of the households were supported by the secondary data from the respective districts of the study areas and from CSA (2011), to compare the base line production parameters of the normal herd with the herds that were infected with LSD (CSA, 2011).

3.3.2. Sampling technique and Sample size Determination

A multistage sampling technique was used to select the study groups. Hierarchically selection was done from region to zone, and district purposively based on livestock population, Outbreak reports, cross border movement of animals for pasture, water search and trade activity, geographical location, and access of transport and population with different farming systems. PA was randomly selected based on lottery system from the selected districts. Households and their respective herds was the final sampling unit of the study. In this study, herd is defined as the collection of different age and sex groups of cattle owned by a single farmer or family members. From the selected district 4 PA and from each PA an average of 26 households or herds was collected with different composition of herd. Systematic random sampling was used for the selection of households and household selection was done after every ten household's interval by exclusion households who had no cattle and not volunteered to participate in the study. However, households who have cattle and voluntary to participate were included in the study.

For the financial assessments of LSD non-probability sampling was followed. Data were collected purposively from t households who have experienced the disease and can define its symptoms for its occurrence in their herd and voluntary to participate in the study. A total of 267 herds which consists of 3442 animals were selected. Some herd owners from risk factor assessments were also included in financial assessments if they fulfill the inclusion criteria.

3.3.3. Data Collection

Structured and pretested questionnaire were used in field data collections. The study approach was based on the herd owners' observation of clinical signs of the disease. Herd owners were asked to describe the clinical symptoms of the disease and triangulated whenever necessary. Commonly occurred skin diseases in the study areas were taken from the epidemiological records of the district veterinary clinic to check for the differential diagnosis of the disease by the herd owners. If farmers able to describe the symptoms and has at least one animal affected in the herd, the herd was considered as infected both for risk factor and financial assessment as described in Radostitis *et al*. (2006). For financial assessment data related to the beef, milk production and the average working days of the draft power were collected from the farmers and from the ministry of agriculture livestock development and the local markets of respective districts. Accordingly, from the four purposively selected districts (Ofla, Alamata, Yallo and Asiyta) 15 PA with 393 total herds which consists of 3539 individual animals were collected. These herds with the individual animals were the number of animals during the occurrence of the disease.

Questionnaire survey

The epidemiological data was collected using questionnaire survey, administered to total of 393 households by face to face interview using local language. The interview takes between 15-20 minutes and was done based on the respondents' local language (Tigrigna and Afarigna). The questionnaire was designed based on the literatures, published questionnaires, in consultation with experts of the disease and some local people from the population to be surveyed. These questionnaires were designed to capture information about the previous outbreaks of the disease, about the environmental and management condition of the cattle and with regarding to the production impacts of the disease. Around thirty two questions were structured which grouped in to five main sections of which the last two main sections were for the financial aspect of the disease.

The first section was about the districts, agro ecologic condition, herd size and structure in the herd and the farm. Second portion consists of previous occurrence of the outbreak of disease consists of lists of questions related to season, year and month of LSD occurrence, frequency of occurrence, LSD sick animals and their sex, age and breed as well as mortality due to secondary complication of the disease. It also includes the herd size and composition or dynamics before and after the outbreak of the disease (Appendix-I). The third section was related with the herd management which includes questions about the seasonal movement of animals, the critical seasons at which the shortage of water and feed faced, farming system, feeding and watering management, contact with sheep and goat, introduction of new animals, livestock market activity and known trade lines near the village and vaccination status of the herd, opinion of the herd owners for the use of the prophylaxis and control of vaccination of the herds.

The remaining sections was dedicated for financial loss assessments in the infected herds such as their herd size and structure, herd dynamics, their management system, number, sex of the animals that had been affected by LSD and subsequently died animals as well as their current prices. Clinical severity of the disease in various age and sex groups was also recorded. In addition to this the respondents asked the structure of the herd before and after the occurrence of the disease. The production losses associated with the disease related to the parameters of milk production, work output losses, beef loss. Market prices of different livestock and their products, treatment costs were also surveyed. The herd owners additionally asked for visiting of the veterinary clinics with sick animals and use of vaccination or treatment before and after the occurrence of the disease (Appendix-II).

3.3.4. Study Variables

During the epidemiological investigation of the disease sets of variables were assessed. These were the associated risk factors and production parameters of financial losses assessments. agro ecological category (Lowland <1500m and highland>2300), Seasonal pattern of the disease, farming system (mixed, pastoral and agro pastoral), watering source (river, pond and well), herd size (small ranged 3-11, medium ranged 12-21 and large 22 and greater). The rest variables were close ended questions, communal grazing and watering points, introduction new animals to the herd, contact with sheep and goat, primary or secondary market activity.

The production parameters such as the milk, beef and draft output loss, mortality and cost related to treatment were among the study variable for the financial assessments of the disease.

3.4.5. Data management and Analysis

Collected data were managed in Excel and all the process of data handling, cleaning, validating and coding was done on the Excel spread sheet Microsoft 2007. Some descriptive analysis and confidence intervals were computed on this spread sheet. The rest of the analysis was carried out using SPSS 16.0 of 2007 by transferring the data from the Excel. Herd and animal level prevalence and association risk factors with prevalence were analyzed using the chi-square test. Logistic regression analysis was used to compute the strength of associations (odds ratios). Variables with a $p < 0.20$ were short listed during univariable logistic regressions to fit them in final multivariable logistic regression. Herd size, contact with sheep and goat, common grazing and watering points, farming system, introduction of new animal in to the herd, vaccination status and source of water for the herds were selected for multivariable regression analysis and variables with statistical significant associations with the prevalence of the disease were set in to the model.

The model set was reduced stepwise by forward removing the factors with the P-value>0.05. The most significant variables set in the model were the effect of herd size, introduction of new animals to the herds and communal grazing and watering points. The effect of pair wise interactions between all factors retained in the final model was tested by Spearman correlation test and to check if any correlation between variables. The confidence intervals for the odds ratio were obtained from the 95% CI of the coefficients of regression analysis and the confidence level for the prevalence was computed in Excel Microsoft 2007. The model fitness was assessed using the likelihood ratios. For cells with observations of (<5), Fishers exact test was used in contingency table.

Financial Impacts analysis

Descriptive statistics was used to calculate the cumulative incidences; mortality and case fatality rates from the questionnaire survey and these variables were computed based on the formula set by Thrustfield (2007). The responses of the herd owners about the severity of the disease at the herd level were ranked as mild, moderate and severe. Confidence intervals of cumulative incidence, mortality rate, and case fatality were computed using the Excel spread sheet Microsoft, 2007. Calculation of other physical losses and cost were also done using Excel spread sheet. Chi-square test was used to compute the probability value (p-value) and significance differences. Cost estimation model for loss due disease was assessed using sensitivity analysis performed by regression coefficient in @Risk 5.7 (Palisade Corporation) implemented on the excel spread sheet by model assigning triangular distributions to the variables as minimum, the average value as most likely and maximum values.

Financial losses related to LSD were assessed based on a one year production cycle based on the outbreak of the disease from the livestock owners' perspectives. Model was developed to estimate the production losses associated with morbidity, mortality and control expenditures but vaccine was given free of charge and it was not considered in the model. The production parameters of local zebu cattle without were obtained from the from CSA (2011) base line data. The farm outputs considered in the model were milk, beef production and draft working output. The model was built in a Microsoft Excel spread sheet 2007 and considers the output losses due the disease. The model was mathematically represented as:

$$TL = A + B1 + B2 + B3 + C1 + C2$$

Where TL=Total loss associated with the disease A= Loss due to mortality

B1=Milk loss, B2= loss of beef, B3= loss of draft work output

C1= loss due to treatment costs, C2= Loss due to opportunity cost

Percentage of the production loss of the beef, milk and draught output was computed using Getachew *et al.* (2010). $Percentage\ loss = (Q/D) * I * 100$, Q=Quantity production lost (milk/L)/lactation, Draft output in days, Off-take rates, D= production parameters of local zebu without LSD (milk off-take/lactation, annual draft output), I=Cumulative incidence of LSD.

In calculation of the financial losses, descriptive epidemiological variables, such as population at risk or the study group, total annual cumulative incidence, mortality rate and case fatality rate were considered. So, to calculate the mortality rate, $A = P * Qi * U$ will be used where p=population at risk, Q=Quantity of disease losses, Qi=Quantity of mortality loss, U= Weighted average price of the animal and the other products. To compute the morbidity losses of milk, beef and draft work output lost; $B = P * I * Q * U$ were used where B= the total morbidity loss, I= cumulative incidence and the rest similar with above quantities. The costs incurred by the disease were manipulated as $C = P * I * It * Ut$ where C = represents the total $costs$ due the disease, It total sick animals getting treated and Ut represents the costs of the disease

The lactating cows at risk of developing the disease and annual cumulative incidence of LSD in female animals and lactating cows during the study period were obtained from the questionnaire survey. The percentage of milk production loss in the study groups was calculated by taking the number of lactating cows and the average lactation length lost due to the disease from an average milk-off take per lactation without LSD in the local zebu and multiplied by cumulative incidence$(Q/D) * I * 100)$. Data of average milk off take per lactation were taken from CSA (2011). Costs associated with the milk loss were estimated from the weighted average costs of milk prices collected during the survey. Lactating cows which died of due to the complexity of the disease during the course of the disease was discounted.

Annual milk production loss and lactation length was estimated in the LSD sick and surviving lactating cows. The average lactation length of milk production loss of the lactating cows that were affected by and survived LSD was estimated to be 50 days lactation-days based on the consideration of chronic nature of the disease, stressing factors such as the long distance travel of the animals for search of water and pasture, aware nesses of the herd owners to bring their animals to the district veterinary clinics, proximity of the clinic from the households. The duration of the milk production loss in sick lactating cow varied with the severity of the disease as the disease remain 2-6 months to recover (Davies, 1991).

Beef production were these proportion of animals solid, consumed ,slaughtered or used for other social purposes rather than the impacts of the diseases in one year production cycle. Beef production loss as a result of LSD was estimated annually as the reduction in output of the percentage off-take rate in the study groups. The total cumulative incidence of the disease was taken in to account and inference to the study groups. Beef production without the disease was taken from the Ethiopian ministry of agriculture and rural development livestock development master plan of (2007) which is ranged 7-9 % an average of 8% was taken. The costs of the beef loss were computed from the weighted average prices of the cattle which were collected during the questionnaire survey.

When survey was carried out in the study areas, information was collected about the impact of the disease in their herds including draught power oxen. Estimation of the draught loss of the oxen in the year was undertaken during the high and low activity of the seasons of the year The costs for draft output power service was calculated by taking the average days between the active and passive seasons of the year. The active season of the year considered here was from January to June, the cropping seasons at which workload for draught oxens and their corresponding demand were high. The rest of the months were considered as seasons at which draught oxen were no more functional. The average annual work load for draught animals were taken as 60 days by considering the religious of the society particularly the Orthodox Church (Azage, 1998). The draught service of the oxen was high during the cropping season and relatively low in the passive one and the weighted average prices of these service prices was taken during the estimation.

Financial losses associated with the mortality, treatment costs and labor opportunity costs were computed based on the collected weighted average prices. The losses associated with the cumulative mortality were estimated from the weighted average prices for each age group collected during the study period. In the present study mortality due to LSD was calculated based on the weighted average price of cattle based on the collected primary and secondary data for each category of the age groups of the calves, bull/heifer and adults animals that had died of LSD. The treatment costs were the costs incurred for the prevention of further complication of the disease for those who brought their animals to clinic. The opportunity cost computed here was considered the herd owners who practices to care their animals by bringing to clinic and taking the recommended medicaments. During the financial estimation of the average weighted prices of the various age and sex groups, data was compared from the household's survey, local trader's questionnaire sample survey, and the prices observation taken by the district agricultural office on market day from the four primary markets of the four districts.

The weighted average prices collected during the market survey were categorized in to three age groups as the price of calves, heifers& bulls and prices of adults. These three prices were summed up and averaged out to the minimum, average and maximum values for the use of beef production losses. The prices of the livestock products such as the price of milk per liter and meat per kg were obtained from the corresponding districts cafes and butchers and this was averaged out as maximum, minimum and average values.

Table 3.Weighted Average Prices of the Cattle and their Products from Districts local market Survey reports

R.No	Cattle and their products	Prices		
		Maximum	Average value	Minimum
1.	Weighted average price of cattle	8200	4900	1600
2.	Weighted average price of calf	2600	2100	1600
3.	Weighted average price heifer/bull	6500	4950	3400
4.	Weighted average price adult	8200	6850	5500
5.	Price of Milk per liter	12	11	10
6.	Beef meat per kg	90	85	80
7.	Draught power service per ox per day	100	90	80
8.	Average Treatment cost	60	55	50

Partial Budget Analysis

The partial budget analysis was used to compute the financial benefit of LSD control at farm or household level in the traditional farming system. This econometric analytical method was used to assess the benefits and costs associated with the control of disease based on the vaccination of the disease. For projects to be advantageous, the costs of control intervention must not exceed the costs of the disease. Under this analysis, fixed costs were not considered. Variables estimated in financial loss assessment of the study groups were also applied to the partial budgets analysis of the target population and the prevalence obtained at animal level from the risk assessment was considered as endemic disease and inference to the target population. The cost estimation was based on the control of the disease to reduce the losses associated with the prevalence of disease. The vaccination against LSD under the extensive farming system was considered to be given to the farmers free of charge and opportunity labor costs that the herd owner would spend to vaccinate his or animal was not taken into account because of the relatively cheap labor cost. The benefit of LSD control was calculated as the sum of the production output that would be saved from being lost as result of the disease in target population and the treatment cost saved. Finally the farm output considered in the model were milk, beef production and the draft work output and the model was developed in the excel spread sheet Microsoft2007.

Table 4.Target Cattle Population in the Study districts of Afar and Tigray Region

District	lactating	Dry cow	Heifer	Draft oxen	Bull	Calves	Total
Alamata	21045	18131	10,453	30320	9113	21040	110,102
Ofla	13520	10750	11720	28670	8954	13516	73614
Yallo	12563	8821	6370	0	8359	12557	36113
Asiyta	24721	11370	9587	2500	7231	24721	80130
Total	71849	49072	38,130	61490	33657	71834	299,959

4. RESULTS AND DISCUSSION

4. 1.RESULTS

Farming System of the Community

The mixed farming system is practiced in 50% of the study groups and almost all of the studied households are males (98%) in both highland and lowland areas of Tigray region. The remaining 50% study group; 20 % of them are pure pastoral (Yallo district) whereas 30% of them are agro pastoral (Asiyta district). The average herd size per household in the study areas was nine heads of cattle ranges with minimum 3 to maximum 38. Communal grazing and watering system utilization was dominant in all farming systems and agro climatic conditions (95.7%) and such practice was 100% in the pastoral and agro pastoral areas.

About twenty three percent of farmers reported that there was an introduction of new animals to their herds either by purchasing, cultural gifts such as marriage or for the purpose of replacement, herd extension or fattening or cattle exchange. Forty nine percent of the herd owners also responded that sheep and goats used to share the same grazing and watering points. Information from the district veterinary offices indicated that most of the farmers (60%) from Tigray region were vaccinated their animals against LSD after the occurrence of the outbreak. However, such practice against LSD in the remaining two districts in Afar region was not experienced. Different local names were recorded for lumpy skin disease from these study districts for instance as ‘dubdbuta’ in Alamata areas and ‘weibo’ in Asiyta areas.

Descriptive Epidemiology and Risk Factor Analysis

For risk factor assessments and financial impact estimations of LSD, a total of 660 questionnaires were collected from the respective study districts. Of these, 393 were from the selected households for risk factor assessment and the rest 267 were from the purposively selected households for financial loss assessments. Risk factor assessments were carried out in the four districts with an average of four PAs from each district with an average number of 26 herds from each PA. An average of nine heads of cattle from each households with total number of 393 herds and 3539 heads of cattle were used for risk factor assessments whereas for financial loss assessments in the same districts and PA were taken and average of 18 herds from each PA with total of 267 herds having 3442 heads of cattle were collected.

Among the total 393 herd owners surveyed from the four districts; 113 questionnaires were collected from Asiyta, 120 from Alamata, 80 from Yallo and 80 from Ofla. The status of the lumpy skin disease from the total herds investigated, 173 herds were found to be infected at least with one LSD cases and out of the 3539 heads and 261 of them were clinically affected. Accordingly, the herd level prevalence was 44% (95%CI: 37-50), but the observed animal level prevalence and average mortality due to LSD in the study areas were 7.4 % (95% CI: 6-8) and 1.92% (95% CI: 1.5-2.4) respectively and the within herd level prevalence ranged from 0-29%.

Higher herd prevalence was recorded in Afar region 51% (95% CI: 40-61) than in Tigray region with 37 %(95% CI: 29-45) and the difference was statically significant (P<0.05). Herd level prevalence among the three zones were vary with higher prevalence 54 %(95%CI: 40-68 in Zone-1 than southern and zone-4 of Afar region with 37 %(95% CI: 29-45) and 48% (95% CI: 33-63) respectively as summarized in table-5. The herd level prevalence of LSD among the four districts was varied from one another; higher in Asiyta 53% (95% CI: 34-67) and followed by Yallo 47.5 %(95 %CI: 37-69) as summarized in table-5.The difference was statistically significant (P<0.05). The animal level prevalence of LSD among the selected districts vary with higher animal level prevalence in Asiyta 9% (95% CI: 7.5-10), lower in both Alamata 6.75 %(95% CI: 5.1-8.4) and Yallo 6.5%(95% CI: 4.4-8.6). These two districts have similar prevalence because of the reason that they share common grazing and watering sources. The least animal level prevalence 4.65 % (95%CI: 2.8-6.5) was recorded in Ofla as indicted in Table-5.

Table 5.Herd and Animal level Prevalence in the Study Regions and Districts of LSD

Factors		Total herds	Herds infected	95% CI	χ^2	P-value
Region						
	Tigray	200	74(37)	28.6-45.0	8	0.004
	Afar	193	99(51)	40-61		
Zone						
	Southern	200	74(37)	29-45	8.9	0.01
	Zone-4	80	38(48)	33-63		
	Zone-1	113	61(54)	40-68		
Districts						
	Asiyta	113	61(54)	34-67	9.92	0.019
	Yallo	80	38(48)	37-69		
	Alamata	120	41(34)	34-44		
	Ofla	80	33(41)	37-69		
	Total	393	173(44)	37-50		
Animal level	Districts	Total head	affected	95% CI animal		
	Asiyta	1504	136(9)	7.5-10.4	13	0.04
	Yallo	551	36(6.5)	4.4-8.6		
	Alamata	947	64(6.75)	5.1-8.4		
	Ofla	537	25(4.65)	2.8-6.5		
	Total	3539	261(7.4)	6.5-8.3		

Higher prevalence of 68% (95% CI: 51-85) were observed in herds with history of new animal introduction into the herds than those without this factor 36% (95% CI: 29.5-43) and the difference was statistically significant (P<0.05). It was observed that higher prevalence in transhumance herds 54% (95 %CI: 40-67) than sedentary 37% and pastoral husbandry systems 47.5 % (P<0.05) herds. Prevalence 84.6% (95 % CI: 34-130) was higher in large herd size than with medium 60 % (95 % CI: 41-78) and small herds 39 %(95 % CI: 32-46) and this significantly different.

Herds with communal grazing and watering point were found to have higher prevalence 45.5% (95% CI: 39-52) than separately grazing and watering herds 11.7% (95 % CI: 0- 32.5). Herd owners who practice vaccinations against LSD were found with less prevalence 36.5 %(95% CI: 28-45) than those not practicing 51.5% (95% CI: 42-61). Herds which use river as water source was observed to have higher prevalence 46.6% (95% CI: 38-55) than those using other sources of water as indicated in table-6).

Table 6. Herd Level Prevalence with different Risk Factors of LSD

Variables	Factors	Total herd	Herd with LSD	95 % CI	χ^2	P-value
Introduction of new animals					29	
	Yes	94	64(68)	51-85		0.000
	No	299	109(36)	29.5-43.0		
Farming system					8.9	
	sedentary	200	74(37)	29-45		0.01
	agro pastoral	113	61(54)	40-67		
	pastoral	80	38(47.5)	32-63		
Herd size					18.5	
	Small (2-11)	315	123(39)	32-46		0.000
	Medium(12-21)	65	39(60)	41-78		
	Large(>22)	13	11(84.6)	34-130		
Grazing and watering point					***	
	separate	17	2(11.7)	0-32.5		0.006
	communal	376	171(45.5)	39-52		
Vaccination status					9	
	yes	195	71(36.5)	28-45		0.003
	No	198	102(51.5)	42-61		
Water source					7.74	0.021
	pond	110	49(44.5)	32-57		
	Well	30	6(20)	4-36		
	river	253	118(46.6)	38-55		

***Fisher exact test was used for small sample size.

During the risk assessments, large proportion the respondents reported that the occurrence of LSD has a seasonal pattern. About 18% herd owners responded that the occurrence of LSD was frequently observed in august followed by September (16%) but seasonally most of the cases were observed in autumn (36% September to November) than the 32% rainy season (June to August). Considerable proportion of the respondents also reported the occurrence of LSD in May (13%) as shown in (Fig.-2)

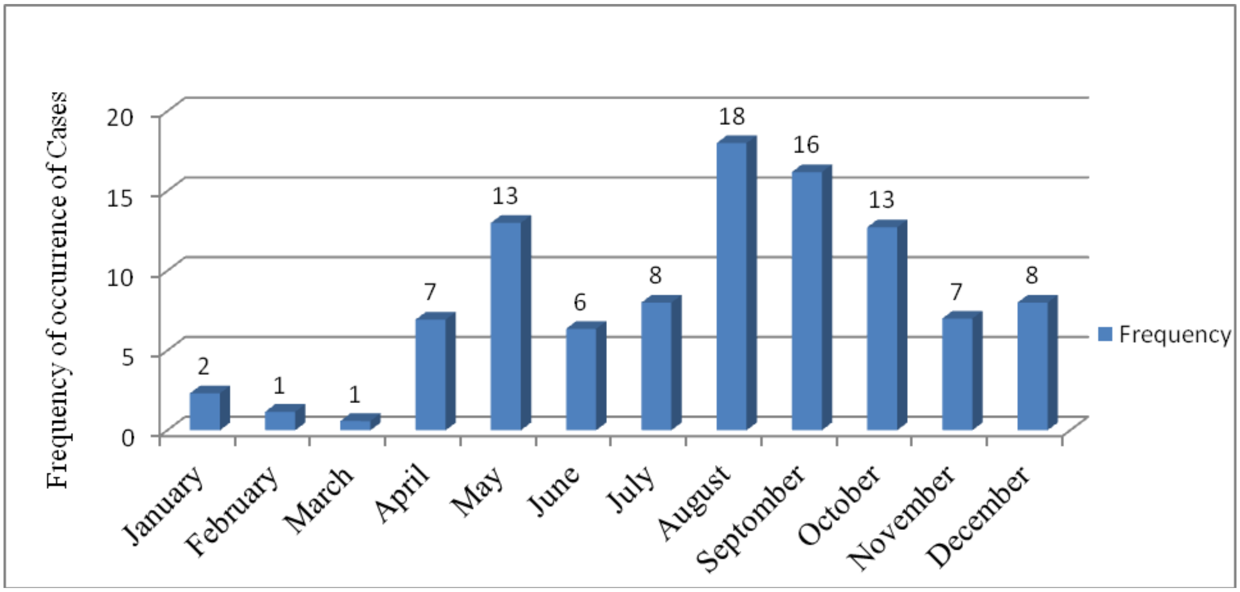

Figure 2. Histogram on Seasonal pattern of outbreak of LSD in different months

Logistic Regression Analysis

Herd size was found to be strongly associated with the prevalence of LSD and herd owners with medium and larger herds were at higher risk of developing the disease as compared to the herds with a smaller number with OR of [2.34:1 (95%CI):1.36-4.04] and [8.56:1 ;(95% CI): 1.9-39.4] respectively. Herds in common grazing and watering area were likely developing the disease as compared to the separately managed herds with OR [6.256(95% CI: 1.4-27.7]. Cattle in agro pastoral areas were also relatively found at risk of the disease as compared to the pastoral and sedentary farming systems with OR [1.99(95% CI) 1.25-3.2] and the herds with the newly introduced animals were strongly associated with the prevalence of the disease in the herd with an odds ratio of [3.72 (95%CI): 2.27-6.1] as shown intable-7.

Table 7. Univariable Logistic Régression Model for LSD

Variables	Factors	Total herd	Herd infected	OR	95 % CI	P-value
Herd size						
	Small (2-11)	315	123(39)			0.000
	Medium(12-21)	65	39(60)	2.34	1.36-4.04	0.002
	Large(>22)	11	13(84.6)	8.58	1.9-39.4	0.006
Grazing watering						
	communal	376	171(45.5)	6.256	1.4-27.7	0.016
	Separate	17	2(11.8)			0.0056
Farming system						
	Sedentary	200	74(37)			0.012
	Agro pastoral	113	61(54)	1.99	1.25-3.2	0.004
	Pastoral	80	38(47.5)	1.54	0.9-2.6	0.106
New cattle introduction						
	No	299	109(36.5)			
	Yes	94	64(68.1)	3.72	2.27-6.1	0.000
Vaccination status						
	No	198	102(51.5)			
	Yes	195	71(36.4)	0.539	0.36-0.81	0.003

The most significant variables set in the model were the effects of herd size, communal grazing and watering points and the introduction of the new animals to the herds. Herds with newly introduced cattle were at risk of LSD than those didn't introduce with OR [4.2:1(95% CI) 2.6-7.5]. The herd size was found at risk of developing disease with [OR 19:1(95% CI) 1.4-50.4]. Contact with sheep and goat, farming system, vaccination status, water source and agro ecology were not significantly associated with the occurrence of the disease by multivariable logistic regression analysis as indicated in table8.

Table 8 . Multivariable Logistic Model for Assocation of Risk Factors with prevalence of LSD ß= Coefficients, OR= marginal value

Factor	β	S.E.	OR	95% CI	P-value
Herd size	2.962	0.912	19.3	1.4-50	0.001
New cattle introduction	1.488	0.268	4.43	2.6-7.5	0.000
Grazing and watering	2.670	0.954	14.443	2.23-94.0	0.005
Constant	-4.362	2.509	0.082		

Financial Impact Analysis

From the 267 herd owners participated in the study, 67 % of them reported that LSD affect their herd severely and the rest (33%) affected moderately based on the number of animals affected in the herd. About 50% of the herd owners were brought their animals to the nearby veterinary clinic. Out of the investigated 3442 heads of cattle which were included in the study of the financial loss estimations 379 animals were found affected with the disease and 66 were died as result of secondary complication of the disease. The production parameters of the study population without LSD specific to selected study areas were obtained from CSA (2011) as summarized in table-9.

Herd structure and herd size of the study groups were obtained from the herd owners during the questionnaire survey of the study districts. About 67 % of the sex composition of the herds was females and rest males 33% might be due to prevailing farming system but for the age category, the proportion of adult females (36%) and males (22 %) were dominating the herd composition followed by calves as indicated in table9.

Table 9. Cattle herd structure from the questionnaire results in study districts

Role number	Description	Sum	Percent
a.	Male cattle	1145	33
b.	Female cattle	2297	67
c.	Calves	727	21
d.	Bulls	290	8
e.	Heifers	458	13
f.	Lactating cows	790	23
g.	Dry cow	437	13
h.	Draught oxen	740	21

Among the 379 affected animals from the four districts, 34% of them were male animals and the rest 66% were females. From the male animals, the adult draft animals were dominant (48%) followed by 32% bulls. Among the female animals 39% of them were lactating cows and the rest 27 % and 26 % were heifers and dry cows as indicated table-10.

Table 10.Description of cattle population affected with LSD by sex and age category.

Sex, age category	District				Total
	Ofla	Alamata	Yallo	Asiyta	
Male calves	3	5	9	15	32
Bulls	4	9	7	9	29
Adult male	24	28	7	9	68
Female calves	3	8	3	6	18
heifers	17	24	6	22	68
Dry female	16	16	12	21	66
lactating	15	24	13	44	98
Total	82	114	57	126	379

The annual cumulative incidence and cumulative mortality calculated for each of the sex and age groups of the study groups were obtained from the questionnaire. The average annual cumulative incidence was found to be 11% (95% CI: 10-12) with the cumulative mortality of 1.9% (95% CI: 1-2) respectively. Cumulative incidences in males 11% were similar to females 10% (95% CI: 9-13.2 and 10-12) and no significance difference between the two sexes. The cumulative incidence in bulls and heifers were higher 15% (95% CI: 12-17) followed by adults 12% (95% CI: 10-13) as compared to calves (6%) and the difference was statistically significant ($p<0.05$) as shown intable-11.

Cumulative mortality were higher in males 3% (95%CI: 2-3) as compared to females 1.4 % (95 % CI: 1-2). It was with statistically significant difference ($p<0.05$) and mortality rate in age groups were higher in calves 3.4% (95% CI: 2-4) followed by heifers and bulls. The total case fatality rate was 17% (95% CI: 13-22). The case fatality rate in the sex category was higher in males 26.4% (95% CI: 18-35) than in females 12.8% (95% CI: 8-17). Comparison among age groups show that the calves 50% (95%CI: 30-69.5) were found to be with high case fatality than bulls and heifers 23.7 % (95% CI: 15-33) and adults 7.9 % (95% CI: 4-12) as seen in table-11.

Table 11.Cumulative incidence and mortality of different Sex and Age groups

Age and Sex category	Total category	Diseased	95% CI	P-Value
Sex category				
Male	1145	129 (11)	9-13.2	0.388
Female	2297	250(10)	10-12.2	
Total	3442	379(11)	10-12	
Age category				0.000
Calf	727	50(6.9)	4-7	
Bull/heifer	748	97(12.96)	12-17	
Adult	1967	232(11.7)	10-13	
Cul.Mortality				0.002
Sex category				
Male	1145	34(2.96)	2-3	
Female	2297	32(1.39)	1-2	
Age category				0.000
Calf	727	25(3.4)	2-4	
Bull/heifers	748	23(3.1)	2-4	
Adult	1967	18(0.92)	0.5-1.3	
Total	3442	66 (1.91)	1.5-2.3	
Case fatality	379	66(17)	13-22	
Sex				0.002
male	129	34(26.4)	18-35	
Female	250	32(12.8)	8-17	
Age				0.000
Calf	50	25(50)	30-69.5	
Bull/heifer	97	23(23.7)	15-33	
Adult	232	18(7.75)	4-12	

Effect of LSD on Milk Yield

The average net milk production of local zebu without disease was 2.823 liter in pastoral and agro pastoral areas of the study districts and in mixed farming system, 1.194 CSA (2011). The average net milk production in the study group is 2 liter with 11.7% cumulative incidence and this was calculated by taking 92 sick cows and 784 total lactating cows by reducing six died animals to avoid double counting of the lactating cows. Accordingly, the loss in lactating cows that survived was estimated in these various farming systems. In pastoral and agro pastoral system, the milk loss due to LSD was estimated to be 141.15 liters per cow per lactation and in mixed farming system; 59.7 liter per cow per lactation in local zebu of the study districts. The average percentage loss in all study districts was 3.26 % (95%CI: 3.16-3.35). The total loss was computed by multiplication of the average days cow felt sick (50 days), milk production per day and the cumulative incidence of the lactating animals (11.7%). The average total milk loss in all the study districts was approximately 9200 liters with the weighted average costs of 101200 birr (5,733.32 USD).

Effects of LSD on Beef Production

The annual off take rate reduction of beef production was computed as the decreasing of the off take rate of the study population caused by the cumulative incidence of lumpy skin disease. Annual beef off take was set by 7-9% and an average of 8% off take rate was taken from the ministry of Agriculture and rural development of Ethiopia (2007). Based on these figures, the percentage annual beef production loss was estimated to be 0.9% (95% CI: 0-6) reduction off take rates for local breeds. This beef loss was estimated by the multiplication of 0.08 with the total study groups and cumulative incidence of the study group (11%) and finally by the weighted average prices to obtain the average financial loss of 147000 birr (8,320.5 USD).The study group taken here was 3376, died animals were deducted to avoid double counting.

Effect of LSD on Draught power

The average duration of draft power output loss was estimated to be 20 days not worked per year for draft ox that had been getting sick of LSD and the estimated percentage loss was 2.56% (95 CI:2.4-2.7). The average loss of the draught power in sedentary areas was 72,000 birr (4,102.21 USD) and this was because of the farmers from these areas kept livestock for the primary purpose of oxen for crop production. The average loss was computed based on the multiplication of the cumulative incidence for the surviving draught power 8% which is calculated by dividing 56 of the sick draft oxen to 728 of the oxen at risk. Study group of draught oxen, the work days estimated and finally the draft work service or rent which account for the average 100800 birr (5,743.10 USD). Died draught oxen were deducted from the draft oxen at risk of developing the disease.

Mortality Due to LSD and Costs of Treatment

An average weighted price of the total costs of died animals were 289650birr (16,502.86 USD). The expenditure incurred for the treatment of the disease as well as the opportunity costs for the labor were calculated based on the information obtained from the district veterinary officer but vaccination was provide free of charge for the households. Labor cost was estimated by the percentage of farmers who brought their sick animals to the clinic. From the questionnaire 20% of the pastoralists and 80% of the farmers from mixed farming system were found to bring their animals to clinic, from this the average percentage was 50% and an average of three days for the outpatient to finish the medicament given was taken. Based on this, 190 of the patient animals getting treated with the 50 % of the herd owners 134 individuals with 35,peridium for the estimated three days. Average cost of 14070 ETB for the labor cost and 10450 ETB for the average cost, a total of 24,520 birr (1,397.03 USD) was wasted. The overall production losses from all parameters were (663,271.00 ETB=37,789.99 USD).

Table 12. Average estimation of production Losses and Estimated Costs

Financial loss			Percentage loss (%)	Average production loss	Max	Average	Min
Milk loss	Pastoral and agro pastoral		3.26	7622	91464	83842	76220
	Mixed crop livestock			2269	27228	24959	22690
	Total			9891	118692	108801	98910
	Average of districts			9200	110400	101200	92000
Total work output loss	Pastoral and agro pastoral		2.56	320 days	32000	28,800	25600
	Mixed crop livestock			800 days	80,000	72,000	64,000
	Total			1120	112,00	100,800	89,600
Annual beef off take reduction			0.9	30	246000	147000	48000
Annual mortality loss total	calf	25			65000	52500	40000
	Bull/heifer	23			149500	113850	78200
	Adult	18			147600	123300	99000
	Total	66			362100	289650	217200
Total treatment costs					11400	10450	9500
Opportunity labor cost					15000	14070	17000
Averaged Total costs					843262	663271	438280

The total losses from the various parameters were generally set by percentage losses for each parameter. The most important losses were due to the morbidity of the disease (53%) followed by the mortality (44%) of the disease and to lesser extent losses due to the treatment costs and the labor opportunity costs.

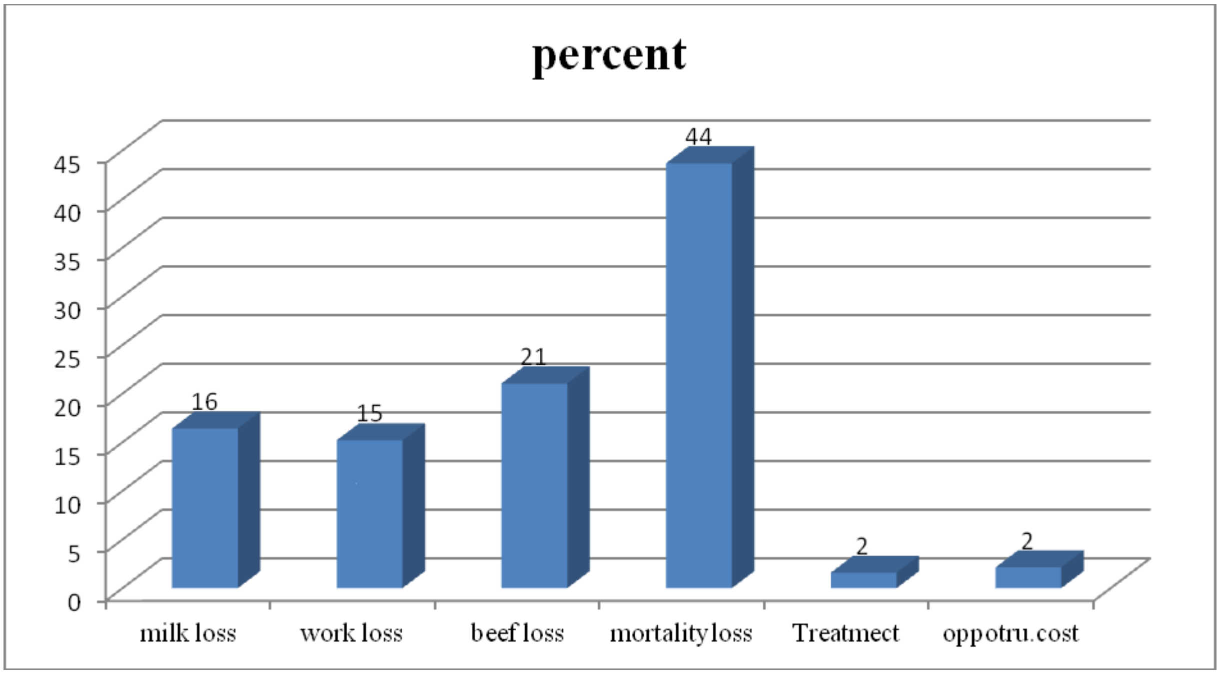

Figure 3. Histogram on the Financial loss of LSD due to different production parameters

Sensitivity analysis

The results from the sensitivity analysis, the beef off take reduction is highly subjected to uncertainty due to the crude estimation of the existing percent of the off take rate which was taken as an average of 8% studied in 2007 and this uncertainty in the output of a model can be apportioned to these and other sources of uncertainty in the model input for beef loss. Treatment cost contributes almost insignificant variation to the overall estimation. Opportunity labor cost was not included in the model, because its value contains only the most likely estimate without lower and max limits.

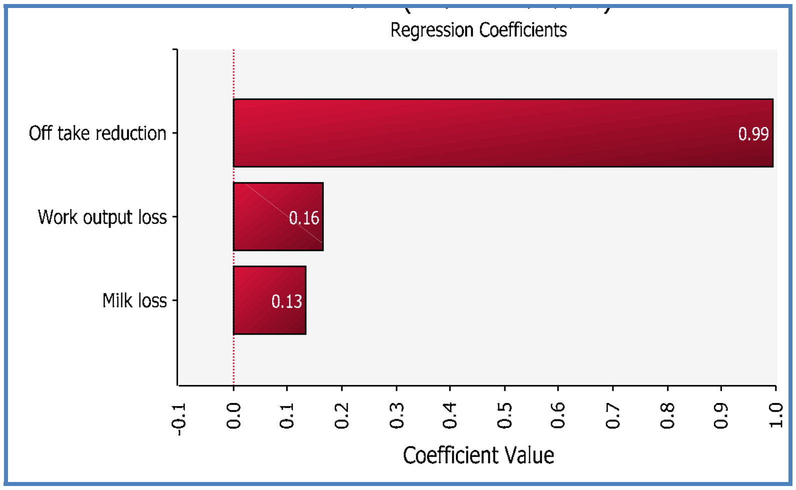

Figure 4. Sensitivity of estimated variables calculated by regression coefficient

Financial Benefit of LSD Control

The calculation of the benefit obtained from the disease control was done by taking the prevalence of the disease obtained from the risk factor assessment at individual animal level (7.4%) and by considering the endemic nature of this disease in the target population of the study districts. The variables for the production parameters of the lactating, draught oxen and beef production were taken from the financial loss estimation of the disease loss. The new costs (vaccination cost) and the revenue forgone was zero as a result of free of charge vaccinations and the cheap labor costs. The new revenue obtained was from the increased milk, beef and draft work output and costs saved from the treatment of the disease.

Table 13.The total obtained gross benefits from the control of the diseases

Parameters	**Benefits Obtained**
Milk production increase	2,924,254.3
Beef Production Increase	8,701,210.670
Draft power output increase	8,190,468
Treatment cost Saved	1,220833.13
Total	21,036766.10= 1,198,573.67 USD

4.2. DISCUSSION

Lumpy skin disease is a notifiable disease and causes severe economic losses due morbidity and mortality. Control of the disease based on the analyzed epidemiological and economical information might result in financial benefits for herd owners. For this reason, the study of the prevalence of the disease has paramount importance to determine the status, risk factors and impact of the disease in given area. In this study, investigation of the disease was based on the farmers' diagnosis of the disease, their experience of observation on their herds for the apparent clinical symptoms and with consulting veterinarians in study districts to obtain data on outbreak reports. Because of the fact that data on individual sick animals and associated risk factors was difficult to obtain from farmers assessment was only done on the prevalence of the disease at herd level with its associated risk factors.

Commonly occurred skin diseases such as demodicosis, dermatophillosis and ring worms were taken in to consideration for differential diagnosis during the questionary survey. Herd owners response on the symptoms of LSD was crosschecked by asking additional questions on the disease. The only limitations that might affect the herd prevalence from the clinical observation of the disease by the farmers were mild forms of the disease. The problem that faced during the data collection was some herd owners refrained to give herd size and composition information for which it was a reason for missing recoded data about the dynamic of the herds. Some of the farmers also believed that a single vaccine can protect to all kind of diseases and when asked about the vaccination against LSD, they didn't identify it from the other. For this reason to collect data on vaccination, we decided to visit recorded data from the respective districts.

LSD prevalence and Risk factor analysis

The present study indicated that the magnitude of the impact of LSD and its frequency of occurrence was varying in different areas. The average herd level prevalence of LSD in this study was 44% which accorded with different reports (Thomas, 2002; CFSPH, 2008; Brenner *et al*., 2009). In Ethiopia, the observed herd level prevalence of LSD reported was 22.3%, 55.2% and 43.5% in highland, midland and lowland areas respectively with the average prevalence of 42% (Getachew *et al.,* 2010). Average herd seroprevalence of 46 % was also reported from three agro climatic zones of highland, midland and lowland areas of Ethiopia (Getachew *et al*., 2012). The observed similarities among different findings might be due to the occurrence of the disease in all ecotypes (Davies, 1991) and the outbreak of the disease was mostly association with the prevalence of insect vectors, host susceptibility, livestock density at grazing and watering source, husbandry systems, wet seasons and agro ecologic conditions, presence of moist, humid, climatic conditions, market activities and introduction of new animals from far areas without screening (Ali *et al*.,1990;Tuppurainen and Oura,2012).

The disease was highly prevalent in Afar region as compared to Tigray region. This could be due to the congregation of animals around the watering and grazing points and mass migration of the animals for search of water and pasture, and possession of large herds for as their main stay (Bossche and Coetzer, 2008). When large herds congregate around the water bodies, the presence of infected animals contaminates the pasture and water sources by releasing the virus through saliva and nasal secretions and vectors survive and breed near these water bodies and hence increase the biting rate of the insect; feed on the infected animals and transmit the virus to the susceptible host (Tuppurainen and Oura, 2012). In the contrary, the cattle population in Tigray region was kept primarily for draught power purpose and uncommon to keep large herds by single farmer and no mass movement of herds for search of water and pasture and this could be the possible reason for the lower prevalence of the disease.

At both herd and animal level prevalence of the disease, Asiyta was high as compared to others. This could be due to the moist, humid climatic condition and the presence of over flowing and irrigated water in the area which might facilitate condition for insect vectors breeding and enhancement of disease transmission (Ali *et al*., 1990; Davies, 1991; Tuppurainen and Oura, 2012). It is assumed that moist climatic condition with rainy season and the end of long rainy months might be associated with the increasing of biting fly population. The animal level prevalence observed in this study was 7.4 %. Similar results reported from Ethiopia (8.1%) (Getachew *et al*., 2010) and slightly higher prevalence (10%) from Kenya has been reported (Davies, 1991). The apparent mortality rate in the present study was 1.92 % which was greed with 1.8 % of the recently reported results from Egypt by Salib and Osman (2011) in Egyptian cattle.

LSD was mostly associated with rainy and wet seasons or with the humid, moist climates. Summer months of august and beginning of autumn might be associated with the increasing of fly populations and feed on the blood of the animals (Tuppurainen, 2005). Based on the results from the respondents, the frequency of the occurrence of the disease was at its peak in summer and autumn months of August and September in the study area. The occurrence of the disease was reported from different areas as it associated with the rainy season or as it occurs wet low lying areas (Ali *et al*., 1990; Bagla, 2005; Getachew *et al*., 2010) as reported from Egypt and Ethiopia respectively.

In univeraible logistic regression analysis communal grazing and watering management, introduction of the new animals to the herd, herd size, farming system, and watering sources were risk factors associated with the prevalence of LSD. Herds at communal grazing and watering points were six times at risk of developing the disease than separately grazing herds. Intermingling of different herds from various areas increases the frequency of herd contact, enhances the chance of spread of infection as a result of the mixing of infected herds with the uninfected animals Ocaido *et al*. (2009). LSD can transmit by sharing of the same grazing and watering points as the virus released in saliva and other body secretions and contaminate the water and feed (Tuppurainen and Oura, 2012). Animals rub up each other in close contact and in open wounds; the virus could transmit to susceptible host as high concentration of the virus is in the skin (Thomas, 2002). Vectors increased frequency of multiple blood feeding would increase the likelihood of the spread of the infection in these herds (Getachew et *al*., 2011; Tuppurainen and Oura, 2012).

Introduction of the new animals to the herd was highly associated with the prevalence of LSD and it was four times at risk of the disease than those didn't introduce new animals. Herd owners brought new animals without testing and this might impose risks for the massive outbreaks by newly introduced infected animals (Getachew *et al*., 2011; Tuppurainen and Oura, 2012; Salib and Osman, 2011). Water source for the herds near the villages was observed to be associated with the occurrence of the outbreak due to grazing of the herds near these water courses, the river delta and basins particularly during the shortage of the rains and this is suitable site for the multiplication of the insect vectors which plays great role in the transmission of the virus (Ali *et al*., 1990; Davies, 1991).

Herd size was also associated with the outbreak of LSD and herd owners with medium herds were two times at risk as compared to those with the smaller one and larger herds were eight times at risk of developing the disease than the smaller herds and this might be due to the farmers with larger herds move from one place to another in search of feed and pasture and interact with various herds (Kumar, 2009; Getachew *et al*. (2010). Farming system was found to associate with the occurrence of LSD particularly with the pastoral and agro pastoral two times more at risk than the sedentary one and being highly prevalent in agro pastoral (Ocaido *et al*. 2009). Contact with sheep and goat, agro ecologic variation and vaccination status was not found to associate with the prevalence of the disease and this might be due to the partial adaption of the virus, closeness of the study areas and vaccination of the animals after the occurrence of outbreaks of the disease Getachew *et al*. (2010).

The variables found to fit in to the final model was the herd size, communal grazing and watering points and introduction of new animals to the herd. The introduction of live animals to the new herds or areas was considered as one of the main contributor in spread of LSD in the area and it has been cited as one of the methods of the spread of LSD locally and nationally (Ali *et al*., 1990; Getachew, 2010; Salib and Osman, 2011). Communal grazing and watering points was among the factors for outbreak dynamics of LSD in closer herds with increased rate of biting insects (Kumar, 2009; Getchew *et al.,* 2010).Herd size increases the probability of infection in grazing and watering areas and subjected to long distance travel that increase the incidence rate of outbreak of the disease (Kumar, 2009; Magori-Cohen *et al*., 2012).

Financial impact

Livestock are important in supporting the livelihoods of poor farmers, consumers, traders and laborers throughout the developing world (Mohiddin, 2009). They range from pastoralist for whom livestock are the main stay for them to agro pastoralists and the mixed farming system. Animal diseases are crucial constraints and thus animals of poor people are particularly vulnerable to disease because of the expense, absence or unsuitability of animal-health and production inputs (FAO, 2011). Financial impact assessment of animal diseases was one of the broad frameworks of animal health economics and from the livelihood framework, only few parameters with a simple model was estimated which are mostly direct impacts that can be quantified by monetary values. For the assessment of the financial loss of various animal diseases, the integration of veterinary epidemiology and animal health economics were required (Mlangwa and Samui, 1996).

The financial losses of LSD was computed based on the epidemiological investigation that financial impact of the disease would be possible and, epidemiological variables were first determined. When the financial losses were estimated , physical loses of the disease were first estimated in terms of mortality, reduction in beef production, milk reduction and draft power and this was followed by the losses of monetary values. Costs of treatment and the opportunity labor cost for the herd owner were also considered. Parameters such as the nursing of sick animal at home, the effect of the disease on infertility, abortion, permanent damage of the hide, delayed growth, contribution of the dung for fuel, manure, costs of feed of animals and other socioeconomic consequences were not taken in to consideration because of lack of reliable data and time limitation.

Lumpy skin disease is one of the severe diseases that can exert economic burden in the poor farming communities and the GDP of the nation. As reported from Egypt by Ali *et al.* (1990), the disease is threat of food security for the livelihood of the poor farmers. From both the study population at risk of developing the disease and sick animals, the proportion of females were higher in this might be due to the purpose of keeping livestock for different purposes particularly in areas of the pastoral and agro pastoral farming systems, the livestock keepers were highly dependent on livestock and their products but farmers from the mixed crop livestock production system, the primary purpose for keeping of livestock was for the draught purpose.

The cumulative incidence among the sex category indicated that there was no significant difference between males and females groups and this indicated that both sexes are equally susceptible to the disease but comparison between different age groups of cattle showed that there was high cumulative incidence in heifers and bulls and this might be due to management problems as more attention was given to lactating animals and in the same is true for the mixed farming system care for the draft oxen was given rather than the biological consequence of the disease as malnutrition is one of the immuno compromization that causes the animals to be highly susceptible . The reason why calves didn't become more infected might be due to the maternal protection of the dams that protect them (Barnard *et al*., 1994).

The mortality in age category, calves were with high proportion and this might be due to the severity of the disease in calves and in case of case fatality rate calves still in high proportion which might be with a similar reasons. Mortality also higher in males than the females due to more work load than the females in particular emphasis during the cropping season where there was no ample food and to the contrary more working and became highly stressed and corresponds with Getachew *et al.* (2011).

The production losses due to LSD were varying in different parameters depending on the purpose of the livestock kept. LSD is disease of lactating cows which cause a sharp reduction in milk yield up to 50% in infected herds (Woods, 1988) and this might be due to secondary complication of mastitis and generalized malaise (Tuppurainen and Oura, 2012). Other report by Kumar (2011) said that the disease result in milk production drop of 40-65 % these results indicated that the disease is very important economically particularly in those livestock keepers whose mainstay is on livestock and their products. The present study compares the variation in farming system in different districts and high milk loss was observed in the pastoral and agro pastoral and the main reason for this was due to high prevalence of the disease and keeping of large proportion of cows for milking and other products.

The estimation of the losses of the beef off take rate due to the interference of lumpy skin disease was considered in the study (Thomas, 2002). The incidence of LSD had a great impact on herd dynamics beef farms as the disease causes emaciation and long convalescent period which take several months to recover. This might cause the loss of market opportunity or reduction in the surplus production of the households (Tuppurainen and Oura, 2012). The disease also has a long term debilitating effect and long disposal time and might also cause mortality in different age groups (CFSPH, 2008).

LSD is one of the draft animal diseases which interfere with the livelihood of the farmers during the cultivation of land during the cropping season of the year (Thomas, 2002). LSD sick draft animals were unable to work properly because of lameness, generalized fever, loss of appetite and stressing factors of the disease. During these seasons farmers suffer from lack of power beyond the estimated costs as the fluctuating rainfall affect them. If they don't cultivate and sowing the crops timely, they will suffer hunger as the crops they produce were their annual feeds (CFSPH, 2008). The farmers were also unable to pay for the hired draught animals during these seasons. So, the disease is a question of the food security in the poor households.

The average total losses of the diseases was summed to be 663271 ETB from the diseased animals and on break down to individual household, they loss an average of 2484 ETB from an average herd consisting of 11 heads annually and 193 ETB from the average animal level holdings and this result was higher than the report by Getachew *et al*. (2010) by 106.2236 and this might be due to the exponentially increased prices of livestock and livestock products, and wide spread of disease across the country. Among the major constraints of the livestock production systems, disease and the subs consequent mortality was one of responsible factor to aggravate the household economy (CFSPH, 2008). As indicated from study 53 % of the total losses were due the morbidity of the disease; productivity losses due to milk, beef and draught power were higher than the losses by mortality which was found to be 44 % of the total losses. Out of the total loss, 97 % losses were due to mortality and morbidity and the remaining 3% derived from the costs for treatment. From the costs of the treatment considered here 50 % were used for the treatment costs for prevention of secondary complication and the rest 50 % were the opportunity costs of the labor.

From these results, the benefit obtained from control of the disease is economically feasible that LSD can be controlled by the mass vaccination of the herds before the coming of rainy season. As Preeze (2006) reported that animals can develop a solid immunity after recovery from infection and in endemic areas cattle should vaccinate every year to prevent and to keep under control the severe loss of the disease and consequent disturbance of the food security. The net benefit obtained to the herd owners is beyond this as there are severale benefits obtained from the control of the disease more than the present study considered three parameters of milk, beef and draught power. The disease was highly prevalent in the developing world where most of the people heavily dependent directly and indirectly on the livestock and their products of Africa and Middle East and needs a joint venture to control with the feasible control costs.

5. SUMMARY AND CONCLUSION

During the present study the overall herd level prevalence was determined to be 44% and the major risk factors associated with the occurrence of the outbreak of the disease was the introduction of the new animal to the herd, herd size ,communal grazing and watering points and wet seasons of the year particularly the beginning of autumn. The financial losses associated with the occurrence of the disease was estimated 193 ETB annually from a single head of cattle. The net financial benefit obtained from the control of the disease was 70 ETB from each head of cattle. Based on these conclusions the following recommendations are forwarded.

- Awareness should be created among the herd owners on the preventive measures of the disease using vaccines before the coming of wet seasons
- Awareness on isolation of clinically sick and newly introduced animals should be created in the herd owners with particular emphasis to those using common watering and grazing points and those with larger herds
- Herd owners should have good understanding on the magnitude of the economic damage of the disease, so that they can practice control measures for better benefit from their livestock
- Prophylaxis and control vaccination should be expanded at these areas as the disease causes significant production losses on milk, beef draft power, permanent damage to hide skin and other losses
- In pastoral and agro pastoral areas ,problems of access of vaccines should be addressed adequately before the coming of dry seasons as animals migrate for search of pasture and water

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7. APPENDICES

Appendix I. Questionnaire Format for Epidemiological Investigation of LSD

I. Background and administrative levels of study areas

Name of the owner _____________ Sex___Age____District_________ Keble______date interview________Region_______Zone______District________Geo.location_________

Herd structure and size

Total No of Cattle in Kebelle

Ox__________ Bull______ L.Cow____

D. cow_____Heifer______

Calf______N° of exotic Cattle _____

Calf_______

No of Cattle in Farm

Breed____Ox____ Bull______

L.cows____ D. cow______

Heifer______

II. The History of LSD Occurrence

1. What are the common skin diseases of cattle in your herd? ___________________
2. Have you had LSD in your cattle? Yes ☐ No☐
3. When did the disease commence in the area (Kebele)? Season _____Mon____ year____

Have you seen such outbreak in the area before this time, < 1yr__ 1-2 Yrs___2-3Yrs___ >3Years___,

4. How frequent LSD reoccurs in the area? Don't Know __Every 1yr__ Every 2yrs__ >3yrs__
5. Total herd size of the farmer before onset of LSD_______: Herd structure Ox____ Bull____ Beef____ Lactating cow______ Dry cow_______ Heifer______ Calf_____
6. How many animals had got sick and died due to LSD among the herd __________

6.1. Clinically sick animals				
Animal code	Breed	Sex	Age	Clinical signs
1.				
2.				
3.				
4.				

6.2.Animals died of LSD			
An. Code/name	Breed	Sex	Age

III. Herd Management

7. Do you move your cattle to other place for grazing seasonally? Yes /No
   If yes, when_______, where _______, how long did you keep them there_______?

8. Grazing and watering resource managements

Grazing/watering mgt | **Farming system**

Communal________ | Pastoral___________ Semi-pastoral___________

Private ___________ | sedentary _____________Mixed___________

Zero grazing______ | Semi-intensive________

Free grazing_____

Type of feed | Watering system | critical season for shortage of water and feed

Natural pasture | River

Cultivated pasture | Stream | **Contact with sheep and goat**

Cereal Straws | Well | Yes / no

Stover (sorghum and maize) | Pond

Salt and Mineral, concentrate

9. Have you bought new cattle or introduced new cattle since 6 months before the onset of the outbreak? Yes/No, if yes, origin of the cattle, number, sex and age? ____

10. Name and distance (in km) of livestock market frequently used and the known cattle trade route around their area. ____

11. Did you vaccinate your cattle for LSD? Yes_____ No________.
If yes when? Before LSD onset____ Specify time_______ After LSD onset ____

12. Number of animals get sick (No of sick/Total no of cattle________ Total no of animals get sick from the vaccinated (No of sick /Total no of cattle vaccinated______no dead (no died/total cattle____),no dead from vaccinated (no died/total no vaccinated_____)

13. Is there any difference b/n the vaccinated and unvaccinated animals in the severity of the disease____________opinion of the owner on the vaccine_______ what to do in the future__________

Appendix II.Financial Impact of LSD

I. Back ground Information of the Respondents

Name of the respondent_____________ Sex___Age____District_________ Keble______

Date interview________Region_______Zone______District________

Herd structure and size

Total No of Cattle in Kebelle

Ox__________ Bull______ L.Cow____

D. cow_____Heifer______

Calf______N° of exotic Cattle _____

Calf_______

No of Cattle in Farm

Breed____Ox____ Bull______

L.cows____ D. cow______

Heifer______

II. Financial Loss Data

a. Do you consider LSD as an important disease and how do you score it? Severe☐ Moderate ☐ Low☐

I. If you consider as an important disease, did u bring your sick animals to the clinic?

Yes ☐No ☐

II. What are the major losses you encountered associated with the disease?

b. Number of LSD died animal, and estimated current price of each?

c. Mortality due to any other disease/case in that particular year

b)An.name	Breed	Sex	Age	Price(birr)	c)An.name	Breed	Sex	Age	Price(birr)
1.					1.				
2.					2.				
3.					3.				
4.					4.				

d. In (♀) = Breed affected _____N° of lactating cow(s): ________; dry cow(s)_______ and heifer(s)_______. Did you milk LSD infected cattle? Yes ☐ No ☐

If say yes; how many cups of milk per milking during the acute case of the outbreak?

An.Code /n°	Production stage of ♀	Parity	Lactation stage During LSD onset (mon.s)	How long days felt sick	Lactation continued or Stopped	Milk Prod. loss		
						B/re LSD	A/r LSD	Total Loss
1.								
2.								
3.								
4.								
5.								

e. How many pregnant females aborted, in number ________ f. Female animal culled due to LSD_______; other pathological pb________ g). In (♂) affected: Breed _______ N° of draft oxen affected __________

Animal Code/N°	When became sick	Estimated Bwt loss Aver, Min, Max	Av. number of lost-Work days
1			
2			
3			

h. Estimated cultivable land area per ox/day______________________

i. Local price of draft ox service per day: max_____ mod______ min______

j. Extra-time expended for medical care of sick animal (in terms of hrs/day* n° of days): max______ min_______

k. Cost of medication in birr/animal Max_______ min________ Total expenditure________

l. Herd management: Indoor feeding ________; free ranging_________

m. Feed: Price of straw/donkey pack_______; Hay/hip______; Silage/kg ______ Concentrates/kg ______

III. Labor costs:

n. Estimated Labor cost per month or year for: Herdman labor __________; Milker_____cleaner__________; Casual labor cost__________________

o. Housing: Fenced stable __________; House barn___________

p. Total off-take in the year: _____ sold; ________; culled_______; Slaughtered _________; given out for others_______

q. Total animal brought during the past one year: ____________

IV. Market price data

a) Average **Cattle market** price in that month, **Ox**= Av______ max______ min_____, **Bull** = Av_____ max_______ min_____, **L.cow**= Av______ Max_____ Min______, **D.Cow** = Av____ max______ min_______, **Heifer**= Av _____ max______ min______,

Calf <1year = Av_____ max_______ min ______

b) Average price of **Milk** (lt) in that month: max ______, min_______Beef meat (kg) max______, min_____ Hide= max_____ min______
Dung for feul/sack ________ compost/sack __________.

c) Is your cattle return from market due to LSD Yes ☐ No ☐

d) LSD vaccination cost/animal___________

e) Antibiotic treatment cost/ animal ____________

Appendix III. Local Market, Private farms, Abattoir Survey

I. Background Information and Administrative Levels

1. Name of the respondent_____________Sex Male [ ] Female [ ] Age______ Date of Interview ________Region_________District_______Kebele_______

2. Activity involved: Butcher ☐ Local trader ☐ Abattoir worker ☐ Tannery worker ☐

3. List (and rank) five important health problems of cattle that are affecting market_______________________________

4. What are the major skin disease you know?_________________________________?

II.History of Outbreak, Season of Occurrence and Market Disturbances

1. Have you had lumpy skin disease diseased cattle? Yes ☐ No ☐

If yes how do you score it; V.Sevre ☐ Severe ☐ Moderate ☐ Low ☐

2. Which Season of the year/month is the disease is most prevalent?

3. Market source; Local Farmers ☐ Local traders ☐

4. Did you buy LSD diseased animal from the market? Yes ☐ No ☐

5. If you say yes to question 4, what did you did with that diseased animals

Solid to other trader ☐ Slaughter ☐ Keeping up to recovery ☐

6. If slaughter what did you observe from that diseased animals

Appendix IV. Format Used by respective districts to record the Price list of the Livestock Market in the local and primary market

Weekly data collection sheet for price information of livestock

Site______________

Date_________________

Time______________

Market_______________

Series Retail price supply; Price observation

Species	Sex	Class	Age group	Branch	Grade	Vendor1	Vendor2	Vendor3	Vendor4
Cattle	male								
Cattle	Female								
Cattle									
Cattle									
Cattle									
Cattle									