Developing a livestock traceability system for domestic and export markets in pastoral areas of eastern Africa

Final report of the Standard Methods and Procedures in Animal Health project

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Acronyms and abbreviations

AU-IBAR	African Union–Interafrican Bureau for Animal Resources
CBPP	Contagious bovine pleuropneumonia
DVS	Department of Veterinary Services
ELISA	enzyme-linked immunosorbent assay
FAO	Food and Agriculture Organization of the United Nations
FMD	Foot and mouth disease
FMDv	Foot and mouth disease virus
GDP	Gross domestic product
ICPALD	IGAD Centre for Pastoral Areas and Livestock Development
IGAD	Intergovernmental Authority on Development
ILRI	International Livestock Research Institute
ISO	International Organization for Standardization
LIT	Livestock identification and traceability
LITS	Livestock identification and traceability system(s)
Mmm SC	*Mycoplasma mycoides* subsp. *mycoides* Small Colony
OIE	World Organisation for Animal Health
RFID	Radio-frequency identification
SMP-AH	Standard Methods and Procedures in Animal Health
SOP	Standard Operating Procedure

Executive summary

The Standard Methods and Procedures in Animal Health (SMP-AH) project, implemented by the African Union–Interafrican Bureau for Animal Resources (AU-IBAR) and the Intergovernmental Authority on Development (IGAD) in partnership with local and international partners, aimed to harmonize approaches for the surveillance and control of transboundary animal diseases in the IGAD region. Its activities were clustered into four main pillars, namely,

- Development of a framework for surveillance and control of trade-related animal diseases
- Harmonization of laboratory testing procedures for priority diseases
- Standardization of procedures for quarantine stations in the region
- Enhancement of the technical and coordination capacity of the member states and IGAD

The International Livestock Research Institute (ILRI) led a research study on livestock identification and traceability systems (LITS) to support the development of a framework for surveillance and control of trade-related animal diseases (Pillar 1). Research activities implemented under this component were:

- An on-farm trial to test the practicability of using back tags as an identification device in the rangelands (back tag experiment)
- A LITS stakeholder workshop
- A situation analysis to document LITS activities in the IGAD region
- Pilot studies on LITS in selected value chains in Kenya and Uganda
- Risk assessment in the Borena-Adama value chain in Ethiopia to support LITS interventions that were being introduced there

These activities were implemented between June 2013 and April 2015. A summary of the achievements of the activities is presented below.

Back tag experiment

The SMP-AH project planned to introduce back tags in the region as one of the animal identification devices given their low cost of production and ease of use. Back tags had not been used locally and hence there were no data to show the duration over which they could remain intact when used on different livestock species. A field experiment involving 10 sheep, 10 cattle and 10 camels was implemented at Mpala Research Centre in Kenya to test the use of back tags for animal identification. The devices were glued on the forehead, right and left shoulder, right and left hip, and tail head of the animal so that each animal carried a total of six tags. The mean number of days between the application of back tags and their detachment was determined by species and site of placement and analysed as time-to-event data. It was found that back tags could remain intact on the skin of an animal for up to a month, especially when glued on the hip or the shoulder. This period was longer than the average interval of 3–4 days when an animal was in the market chain and hence this tag could be effectively used for market livestock. The study established that there is need to sensitize market actors on the usefulness of this device since it had very low levels of acceptance when it was introduced as one of the identification devices for the LITS pilot studies (Activity 4).

LITS stakeholder workshop

A LITS stakeholder workshop was held at ILRI Addis Ababa on 4–5 February 2014. The purpose of this regional workshop was to review and discuss alternative LITS and make recommendations on the most practical options and approaches for use in the pilot study as well as in the development of a LITS framework for the IGAD region. The workshop was very successful in engaging a wide range of actors and its report is available online at http://hdl.handle.net/10568/35630. Most of the recommendations from the workshop have been taken up by institutions such as AU-IBAR and the IGAD Centre for Pastoral Areas and Livestock Development (ICPALD).

Situation analysis on LITS in the IGAD region

The situation analysis sought to document existing practices and policies on LITS and identify entry points for the SMP-AH project and other projects in the region. The countries covered by the review were Djibouti, Ethiopia, Kenya, Somalia (Somaliland), South Sudan, Tanzania and Uganda. LITS experts from each country were identified and contracted to collate experiences from their respective countries based on a predefined checklist. The reports capture data and information collected from each country but in general, there were poor policies on LITS in most countries (except Tanzania) given that LITS were being implemented under the existing animal health acts. The reports also indicate that many countries were in the process of refining their LITS policies to take into account emerging livestock identification methods, such as radio-frequency identification ear tags, since most of them only recognized traditional livestock identification methods such as hot-iron branding. In addition, most of the projects that had been carried out focused more on livestock identification than on livestock traceability. Most of the reports generated from this activity have been used by ICPALD to develop guidelines for LITS in the region.

LITS pilot studies in Kenya and Uganda

Two LITS pilot studies were implemented in selected beef value chains in Kenya and Uganda. Animals were tagged at the primary markets and their villages of origin determined at the time of tagging. The animals were traced along the value chain and their identification data captured in subsequent secondary markets until they reached the slaughterhouses. Value chain actors were interviewed by structured questionnaire to determine their perceptions on LITS. All the data were captured by the Open Data Kit application installed in smart phones. A total of 3114 records from 1186 cattle in Kenya and 1256 records from 607 cattle in Uganda were captured. Thirty-two percent of the tagged animals were traced back to their villages of origin, 39% were traced back to other markets not included in the pilot studies and 29% were traced back to the primary markets covered in the study. Ear tags were the most preferred identification device and most actors associated LITS with control of cattle theft but few could link this to disease control. The study observed that there were huge gaps in LITS capacity among market actors and institutions that oversee livestock trade. Moreover, the existing market infrastructure in the target areas (fences, animal holding crushes, flow of activities and data recording systems) need to be refurbished if LITS are to be introduced in these areas.

Risk assessment in Ethiopia

A risk assessment study was implemented in Borena-Adama value chain in Ethiopia to determine the risk of release of foot and mouth disease virus (FMDv) and *Mycoplasma mycoides* subsp. *mycoides* Small Colony (Mmm SC), the causative agent of contagious bovine pleuropneumonia, through the export of livestock and livestock products (beef). This value chain supplies most of the animals exported from Ethiopia and has been undergoing extensive infrastructural development such as the refurbishment of markets, feedlots and export slaughterhouses. The value chain has also been selected for the piloting of LITS which can trace live animals (mainly cattle) back to the primary markets. A risk assessment workshop was convened at the start of this study to define the risk questions and pathways. The study established that LITS intervention would introduce at least three additional nodes in the risk pathway, namely, pre-market, post-market and holding ground inspections. The additional nodes would increase the number of check points and improve inspection standards, leading to reduced risk of release of FMDv and Mmm SC. These results, in contrast to those of the other activities summarized above, have not been reviewed with the stakeholders and so there is need to subject them to a technical review.

These research activities have created awareness on LITS among the actors as multiple local workshops were held to discuss the interventions that were being implemented. Moreover, most of the outputs generated from the LITS activities have been incorporated in a manual on regional guidelines for LITS developed by ICPALD (available at http://icpald.org/wp-content/uploads/2016/01/Livestock-Identification-and-Traceability.pdf).

1. Introduction

Livestock contribute immensely to socio-economic development of the Intergovernmental Authority on Development (IGAD) region as a source of food and income and as a foreign exchange earner. This represents approximately 15% of the region's overall gross domestic product (GDP) (Sandford and Ashley 2008). Estimates from the Global Livestock Production and Health Atlas of the Food and Agriculture Organization of the United Nations (FAO) show that there are about 210 million livestock units in the region, comprising about 54 million cattle, 10 million camels and 145 million small ruminants in 2013 (http://kids.fao.org/glipha/). Most of these are raised under pastoral or agro-pastoral production systems which account for 53% of the total beef produced in the region, 70% of sheep, 68% of goats and 33% of cattle milk (Knips 2004).

The region has had successful trade in livestock with the Middle East for many years despite occasional disruptions associated with outbreaks of infectious diseases such as Rift Valley fever (Cognolati et al. 2006). According to FAO's Statistics Division, FAOSTAT (http://faostat3.fao.org/browse/T/TA/E), in 2012 alone, 4.9 million livestock units were exported from only four countries: Djibouti, Ethiopia, Kenya and Somalia. Some of the IGAD member countries (Ethiopia, Somalia and Sudan) also export processed meat. The volume of this trade has, however, not been accurately determined given that some of the transactions are conducted through informal networks.

Demand for animal-source foods is expected to increase with rising human population, urbanization and improvement of socio-economic conditions locally as well as in the importing countries. To meet the rising demand, the current levels of production will have to be increased and perennial losses associated with droughts, disease outbreaks, poor access to input services, insecurity and other constraints will have to be minimized. The region is burdened with a large number of transboundary animal diseases such as foot and mouth disease (FMD), contagious bovine pleuropneumonia (CBPP), contagious caprine pleuropneumonia, Rift Valley fever, brucellosis, *peste des petits ruminants* and pox diseases and it is estimated that animal diseases alone are responsible for 20% reduction in production, leading to malnutrition and deficiency of animal derived protein and micronutrients (AU-IBAR 2010).

To address these challenges and hence stabilize local and inter-regional livestock trade, the African Union-Interafrican Bureau for Animal Resources (AU-IBAR) and IGAD developed the Standard Methods and Procedures in Animal Health (SMP-AH) project to harmonize interventions for surveillance and control of transboundary animal diseases. The overall objective of the project was to contribute to reduced poverty and enhanced regional economic growth and integration through improved access to regional and international markets for live animals and animal products. The project aimed to achieve this objective through the development of:

- a framework for surveillance and control of trade-related animal diseases
- harmonised laboratory testing procedures for priority diseases
- standard procedures for quarantine stations in the region
- technical and coordination capacity of the member states and IGAD

Under the SMP-AH project, the International Livestock Research Institute (ILRI) implemented pilot research studies on livestock identification and traceability systems (LITS) to support the development of a framework for surveillance and control of transboundary animal diseases. These studies were implemented at a time when LITS had not been used routinely in the IGAD region and policies that governed their use were inconsistent across the IGAD member states. Most of the projects that had been implemented on LITS focused more on livestock identification than on livestock traceability. In addition, market actors used traditional systems of animal identification which were not amenable to traceability purposes. This report describes the activities conducted, observations made and some of the initial outcomes realized.

2. Activities

A description of the activities is presented in the order in which they were implemented, starting with the back tag field trial, followed by the stakeholder workshop, the situation analysis of LITS in the IGAD region, field surveys, pilot studies and, lastly, risk assessment in Borena-Adama value chain.

2.1. Back tag field trial

2.1.1. Background

The SMP-AH project intended to introduce back tags in the region as one of the animal identification devices given their low cost of production and ease of use. Back tags had not been used locally before so this trial was conducted to determine, on average, how long the back tags remain intact after being placed on the animals, given that livestock in pastoral areas are grazed in shrubby vegetation which could scratch off any device applied on the skin. The field trial was conducted in Mpala Research Centre, Kenya.

2.1.2. Methods

The trial used 10 sheep, 10 cattle and 10 camels. Tags were glued on the forehead, right and left shoulder, right and left hip and tail head of the animals so that each animal carried six tags. The tagged animals were monitored by staff of the Mpala Research Centre and at the end of each day, the status of each tag per animal was recorded.

Figure 1: A bull with a back tag placed on the left hip.

The data collected were analysed using STATA /IC version 13.0. The mean number of days between the application of back tags and their detachment was determined by species and site of placement. For all the sites, there were adequate records for sheep and cattle but not for camels. To assess whether species and site had significant effects on time-to-detachment, a Cox proportional hazards model was fitted to the data. An interaction term (species and site) was included in the model and its significance assessed using the likelihood ratio test. The fitted model assumes that the rate of detachment of a back tag is the product of a baseline hazard and an exponential function of the three independent factors: species, site of attachment and their interaction term. The proportional hazard assumption for all the predictors including the interaction terms was also tested using the *estat phtest, detail command*, all of which satisfied the assumption ($p < 0.05$). To account for clustering of observations at the animal level (given that up to six back tags were placed on each animal), a shared frailty term based on the animal identification was included in the analysis. This term was, however, dropped from the final model since it was not significant ($p = 0.07$).

2.1.3. Results and discussion

The mean number of days between the application of back tags and their detachment in sheep and cattle are presented in Table 1.

Table 1: Mean number of days of retention of back tags glued onto placement sites in sheep and cattle

Placement site	Sheep	Cattle	Overall mean
Forehead	9.0	18.7	14.8
Right shoulder	34.6	30.8	31.6
Right hip	36.3	33.7	34.2
Tail head	19.4	-	18.5
Left hip	31.1	37.0	30.9
Left shoulder	41.1	26.3	30.5

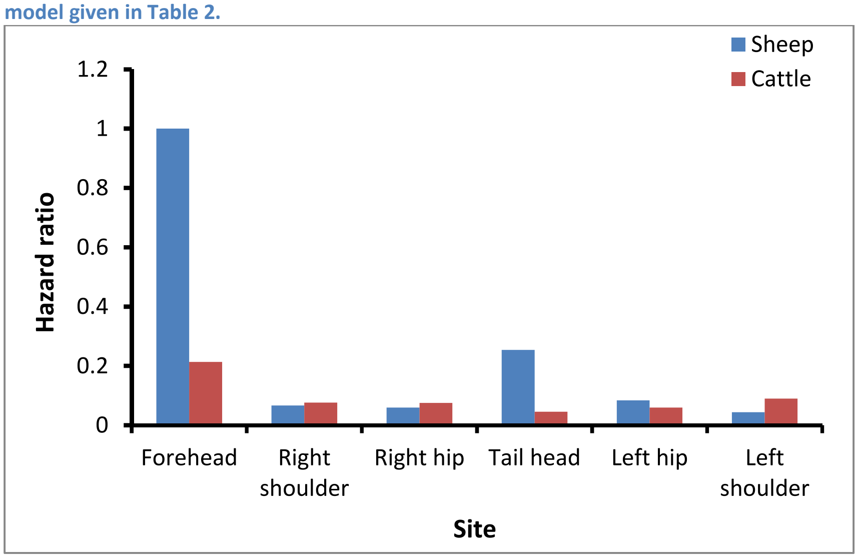
These findings show that tags placed on the forehead and the tail head were more likely to detach much earlier than those placed on the other sites. There was a difference between the two animal species with regard to the site with the longest duration of retention of the back tag: the left shoulder for sheep and the left hip for cattle. These differences are further demonstrated in the results of the Cox proportional hazards model (Table 2) which also indicated a significant interaction between species and site. This interaction term is interpreted graphically in Figure 2 with the reference category being sheep + forehead category. The model and the graph support the trends observed in Table 1.

Table 2: Results of the Cox proportional hazards model used to analyse factors affecting time to detachment of back tags glued to different body sites in sheep and cattle

Factor	Level	Hazard ratio	SE	Z	P > Z
Site	Forehead	1.00	-	-	-
	Right shoulder	0.07	0.04	-5.09	0.00
	Right hip	0.06	0.03	-5.02	0.00
	Tail head	0.25	0.12	-2.88	0.00
	Left hip	0.08	0.04	-4.68	0.00
	Left shoulder	0.04	0.02	-5.58	0.00
Species	Sheep	1.00	-	-	-
	Cattle	0.21	0.10	-3.25	0.00
Interaction	Sheep* Right shoulder	5.34	3.88	2.34	0.02
	Sheep* Right hip	5.92	4.65	2.26	0.02
	Sheep* Tail head	0.84	0.98	-0.15	0.88
	Sheep* Left hip	3.34	2.79	1.44	0.15
	Sheep* Left shoulder	9.52	6.77	3.17	0.00

Number of subjects: 83; time at risk: 2,283; log likelihood: -269.61; P > Chi^2 = 0.00

Figure 2: Interpretation of the interaction term between species and site predicted by the Cox proportional hazards model given in Table 2.



2.1.4. Conclusions and way forward

Back tags remain intact on the skin of an animal for up to a month especially when glued on the hip or shoulder. This was longer than the average duration of 3–4 days when an animal was in the market chain and hence back tags could be effectively used for market livestock. Back tags have, however, not been used before in eastern Africa so there is need to sensitize market actors on their usefulness before they are introduced. Countries that have used back tags have found them to be easy to apply or remove, affordable and readable.

2.2. LITS stakeholder workshop

2.2.1. Background

The LITS stakeholder workshop was held at ILRI Addis Ababa on 4–5 February 2014. The purpose of this regional workshop was to review and discuss alternative LITS and make recommendation on the most practical options and approaches for use in the pilot study as well as in the development of a LITS framework for the IGAD region. The expected outputs of the workshop were:

- Reports on the situation analysis of LITS in the IGAD member states presented, discussed and understood
- Lessons learned from LITS implementation in other regions presented, discussed and understood
- Practical options and approaches for use in the development of a LITS framework in the IGAD region identified and discussed and the way forward agreed upon

The workshop was attended by 35 participants comprising chief veterinary officers and LITS national experts from IGAD member countries as well as representatives from AU-IBAR, the Agricultural Growth Program – Livestock Market Development Livestock Traceability Study in Ethiopia, the Centre for International Security Studies, CNFA South Sudan Cattle Programme, the East African Community Animal Health Desk, FAO regional office and Emergency Centre for Transboundary Animal Diseases, the IGAD Centre for Pastoral Areas and Livestock Development (ICPALD), ILRI, Kenya Livestock Marketing Council and North East Africa Livestock Council.

2.2.2. Workshop outputs

A detailed report[1] of the workshop is available online at http://hdl.handle.net/10568/35630. Key outputs of the workshop were as follows:

- Background reports from IGAD member countries on respective LITS interventions were presented and discussed. These reports were then used to develop the situation analysis report (outlined in Section 2.3.1.).
- The scope of the LITS pilot study was defined; the workshop recommended piloting a system that traced individual animals or groups of animals back to the primary markets from processing points such as slaughterhouses.
- Types of animal identification devices for the region were recommended and listed in order of preference as:
  (a) Visual tamperproof ear tags with International Organization for Standardization (ISO) coding
  (b) Visual tamperproof ear tags (with ISO coding) plus hot-iron branding in insecure areas
  (c) Radio-frequency identification (RFID) ear tags
  (d) RFID bolus (for ruminants)
  (e) Microchip implants (for controlled trials) with hot-iron branding to deter theft

2.2.3. Conclusions

The workshop identified and discussed key issues affecting LITS implementation in the region apart from designing and defining the scope of the pilot study. The workshop report has also been used as a reference document in the development of regional guidelines for LITS particularly by ICPALD.

2.3. Situation analysis of LITS in the IGAD region

2.3.1. Background

The purpose of the situation analysis review was to identify lessons from previous LITS studies for integration into the pilot study, document existing practices and policies and identify entry points for LITS interventions in the region. The countries covered by the review were Djibouti, Ethiopia, Kenya, Somalia (Somaliland), South Sudan, Tanzania and Uganda. The review was done by local experts (one per country) identified through the chief veterinary officers. Topics covered in the review were as follows:

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[1] ILRI. 2014. *Livestock identification and traceability systems in the Intergovernmental Authority on Development (IGAD) region: Proceedings of a regional workshop, Addis Ababa, Ethiopia, 4–5 February 2014.* Nairobi, Kenya: ILRI.

1. Baseline information on the livestock sector
    a. Livestock demographics, geographical distribution, contribution to the national economy
    b. Identification of major sources of live animals for trade, trade routes, destination markets

2. Livestock identification and traceability systems
    a. Description of all types of LITS available in the country by:
        - Types of LITS used by production system
        - Geographical coverage of the LITS
        - Historical trends – when LITS was introduced, how it has been progressing and which areas are doing well or poorly
    b. Purpose of livestock identification (taxation, disease control, security, market access)
    c. Other identification systems used as part of disease control, e.g. mass vaccination programs
    d. Awareness about meat safety and quality and role of LITS in ensuring meat safety
    e. Cost of different programs being implemented

3. Policies and institutions
    a. Description of current laws regulating livestock identification and traceability (LIT)
    b. Penalties for law infringement
    c. Description of institutions enforcing livestock identification laws or related activities
    d. Description of available infrastructure to enforce LIT
    e. Regulations for traders and slaughterhouses

4. Recommendations
    a. Identify the type of traceability system that can work in the country
    b. How can the adoption and use of LIT be enhanced in the country?

To obtain accurate information from each country, in-country research associates were identified through their respective chief veterinary officers and consultancy contracts awarded to them to carry out the reviews. Information generated from the reviews was tabulated and a map generated to show areas where LITS projects were being implemented.

2.3.2. Results and discussion

Background reports were received from seven countries: Djibouti, Ethiopia, Kenya, Somalia (Somaliland), South Sudan, Tanzania and Uganda. Table 3 gives a summary of the information captured in the reports, namely, the contribution of livestock to the GDP of the respective countries, types of animal identification devices used, pilot projects on LITS and policies in place to support LITS.

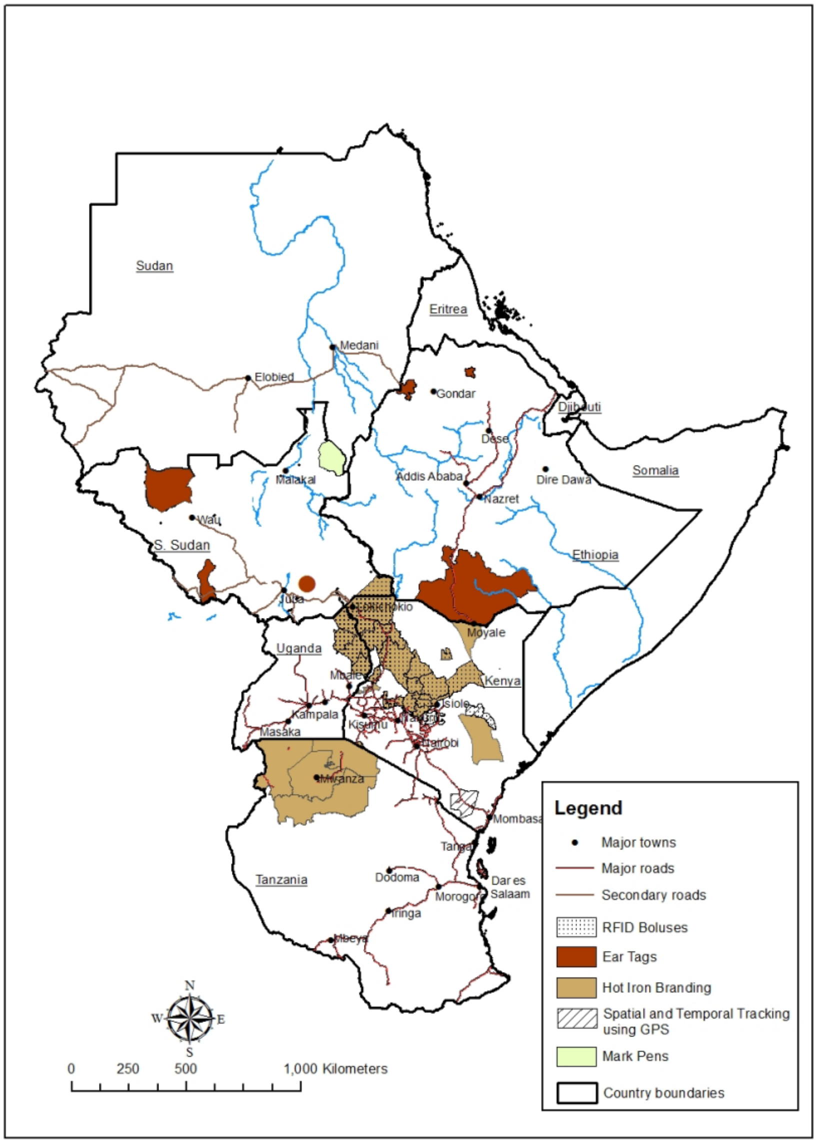
In general, the contribution of livestock to GDP ranges from about 5% in Djibouti, Tanzania and Uganda, 12% in Kenya to 15–40% in Ethiopia, Somaliland and South Sudan. All countries used more or less similar types of animal identification methods such as hot-iron branding, ear notching and ear tagging. Major differences were reported between countries on the range of LITS pilot projects that were being implemented and whether there were adequate policies to guide LITS activities. Ethiopia and Tanzania had plans to initiate LITS based on various identification methods, e.g. tamperproof ear tags in Ethiopia and ear tags, hot-iron branding and rumen boluses in Tanzania. Kenya, South Sudan and Uganda had initiated animal identification projects to support livestock-related insecurity problems and these projects had not been used for traceability purposes. Figure 3 illustrates areas that have been used or identified for various LITS projects.

Apart from Tanzania, all the countries did not have LITS-specific policies; their livestock identification measures were being implemented under existing animal health acts. Many countries were in the process of refining their LITS policies to take into account emerging livestock identification methods such as RFID ear tags since most countries only recognized traditional livestock identification methods such as hot-iron branding.

Table 3: Summary from the background reports on LITS from the countries selected for the LITS situation analysis

Country	Estimated livestock population and contribution to GDP	Animal identification methods used	LITS or animal identification pilot projects	Existing policies to support LITS	Reference
Ethiopia	53.9 million cattle, 25.5 million sheep, 24 million goats, 8 million equines, 50.4 million poultry and 5.2 million beehives. Contribute 15–17% of total GDP and 45% of agricultural GDP.	Painting, hot-iron branding, ear notching and ear tags	Limited to animals destined for export and will start in Borena-Adama. Registration of premises including holding grounds, markets, feedlots, export slaughterhouses, rendering facilities, quarantines, border posts, ports and laboratories among others. Animal identification to be done using tamperproof plastic tags purchased from veterinary stores by animal purchasers. Animals purchased are tagged and transported to a holding ground or feedlot. Recording and management of data using a specialized database.	No specific policy on LITS but the Animal Disease Control and Prevention Proclamation No. 267/2002 provides the required legal framework. There is a proposal to initiate a national LITS advisory committee.	Shitaye (2014)
Tanzania	22.8 million cattle, 7 million sheep, 15.6 million goats, 2.1 million pigs and 61 million poultry. Contribute 4.6% of GDP.	Hot-iron branding, painting, tattooing, ear notching and ear tags	The proposed system is based on hot-iron branding for groups of animals in pastoral settings, visual and RFID ear tags in commercial farms and combination of ear tags and rumen boluses in insecure areas. Hardware system for reading the RFID ear tags and boluses and centralized database. Registration of premises.	A specific LITS policy—the Livestock Identification, Registration and Traceability Act Cap 184, section 5 subsections 6 and 7—passed by parliament in 2010 with a transitional period of three years during which pastoralists would be educated on the act.	Bahari (2013)
Kenya	17 million cattle, 17 million sheep, 27 million goats, 3 million camels, 300,000 pigs, 1.8 million equines, 31 million poultry and 400,000 rabbits. Contribute 12% of GDP.	Hot-iron branding, painting, tattooing, ear notching, ear tags and rumen boluses	A project (Dumisha Amani) using rumen boluses and radio tracking devices was piloted. This involved 130,000 head of cattle in insecure areas in northern Kenya. Challenges encountered were limited technical expertise, inadequate market infrastructure and poor institutional environment.	Branding Stock Act (Cap 357) provides for registration of animals.	Maritim et al. (2014)
Somaliland	1.5 million cattle, 7.5 million sheep, 6.8 million goats and 300,000 camels. Contribute about 40% of GDP.	Painting, hot-iron branding, ear notching, wooden bell collar, plastic or metal tags, microchips, global positioning system collars in camels, naming, owner's phone number markings and barcodes	None identified	No specific policy on LITS. Identification of animals for trade is described in the Somaliland Veterinary code. Animal welfare issues related to identification are captured in Article 4 of the Somaliland National Animal Welfare code.	Ali (2014)
Uganda	12.8 million cattle, 4 million goats, 3.8 million sheep, 3.6 million pigs, 42.1 million chickens. Contribute 5% of GDP and 13% of agricultural GDP.	Hot-iron branding, rumen boluses, ear tags and ear notching	Electronic identification of cattle in Karamoja using rumen boluses to enhance security. Ear tagging is used in other parts of the country as part of dairy herd management.	No specific policy on LITS. Branding of Stock Act (1964) was disbanded during the civil strife. The Animal Breeding Act (2001) replaced the above though it focuses on breeding and does not provide for alternative identification methods. The Agricultural Development Strategy and Investment Plan also supports animal identification strategies.	Kyokwijuka (2014)
Djibouti	40,000 cattle, 1 million sheep and goats, 50,000 camels, 6500 donkeys and 6000 poultry. Contribute 3–5% of GDP.	Hot-iron branding, ear tags and bells	None	No specific policy on LITS. The ministry has various policies on livestock movement, animal health and animal production.	Elmi (2014)
South Sudan	11.7 million cattle, 12.4 million goats, and 12.1 million sheep. Contribute 15% of GDP.	Colour of animal, ear tags, markings, bells/ rope on neck, naming, branding, tattooing and ear notching	South Sudan Cattle Project is piloting the use of tamperproof ear tags to control cattle theft. Traceability components not included.	None existing currently but bills are being developed.	Araba (2014)

Figure 3: Map of sites that have been used or identified for LITS projects in the eastern Africa region.



Source: ILRI Geographic Information System team

2.3.3. Conclusions

The situation analysis showed that there have been many projects on livestock identification in the region but none on livestock traceability. Ethiopia and Tanzania were developing new projects on LITS in Borena-Adama and northwestern Tanzania, respectively. These projects are currently developing the necessary infrastructure, such as restructuring of the target value chains to include pre- and post-market check points and animal holding areas, databases and associated data forms. The situation analysis also showed that except for Tanzania, most countries do not currently have LITS-specific policies. Accordingly, animal identification measures are implemented under animal health or security acts which, to a large extent, do not adequately cover some aspects of traceability, for example, the need to declare sources of animals in the market chain or even the legislation of some of the identification methods.

On the commonly used identification methods, the review identified naming, hot-iron branding, tattooing, notching and collaring among others. Notching is specifically associated with the rinderpest eradication program since it was used to identify animals that had been vaccinated. The review suggested that countries set up policies to support LITS implementation, e.g. enforcing actor participation when compliance is low.

2.4. Pilot studies

Following the recommendations of the stakeholder workshop, two LITS pilot studies were implemented: one in the Northern Tanzania-Narok-Nairobi value chain and the other in the Karamoja-Soroti-Busia value chain in Uganda.

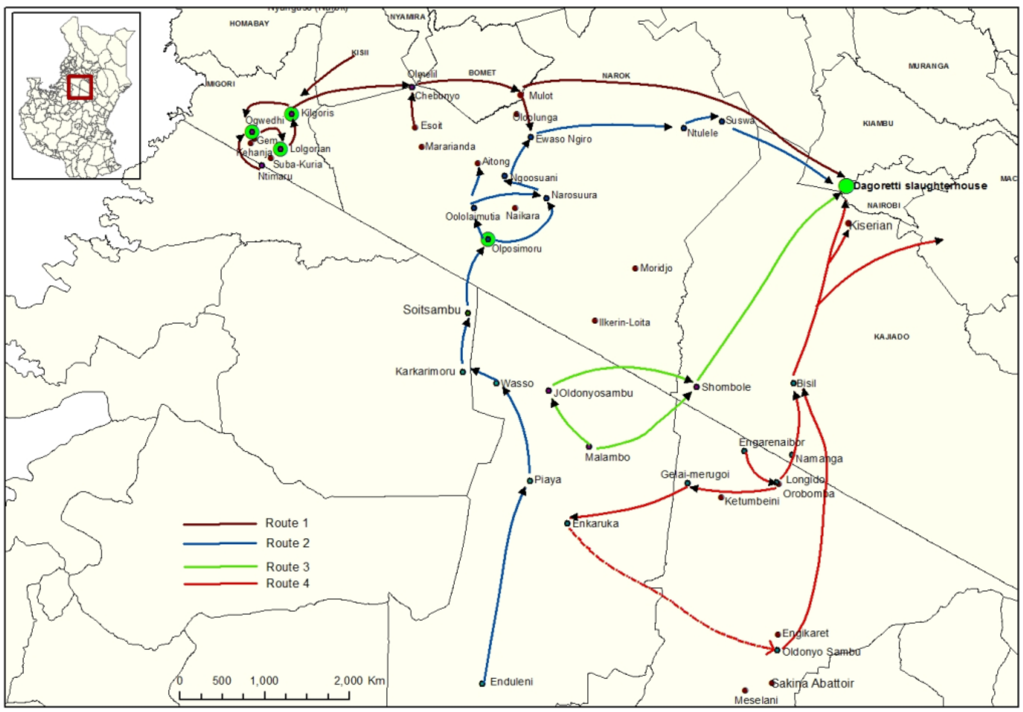
2.4.1. Northern Tanzania-Narok-Nairobi value chain

2.4.1.1. Methods

Mapping the study sites

Markets and slaughterhouses for the study were identified and mapped (Figure 4). The sites were visited and their locations marked using hand-held Garmin e-Trex® Global Positioning System receivers. Geographic coordinates were recorded in degree decimals. The locations were then mapped using ArcGIS version 10.3 (ESRI, Redlands, CA).

Figure 4: Map of identified markets and slaughterhouses for the pilot study in the Tanzania–Kenya pilot study.



Development of data collection forms and a database

Data collection forms and a database were designed and pre-tested before use. Three types of forms were used: (i) market entry and exit, (ii) slaughterhouse and (iii) laboratory samples. The market entry and exit forms captured characteristics of animals and owners at entry and exit from the primary, secondary and tertiary markets. The slaughterhouse form captured diagnoses made during post mortem examinations conducted at the slaughterhouse. Types of data collected at each of these points are described in Table 4. Unique animal identification numbers were included in the forms to allow for merging of data collected from the same animal at different points in the market chain.

The forms were designed using Open Data Kit Collect (https://opendatakit.org/use/collect), a smart phone application that runs on the Android operating system. An online database was designed and hosted at the ILRI research computing cluster (http://azizi.ilri.cgiar.org/aggregate). The database was linked to the smart phones used in the field using 3G internet provided by the local mobile phone companies.

Table 4. Description of the types of data collected during the LITS pilot study

Subject	Characteristics
Status	Specify if entry or exit or stock check
Animal	Identification number and method (ear tag, back tag, paint)
	Status (entering or exiting the market)
	Source (farm or market)
	Next destination (market, farm or slaughterhouse)
	Sex
	Colour
	Age category
Owner	Name
	Producer or trader
	Telephone contact
Market	Name
	Geographic coordinates
Slaughterhouse	Trader's details (name and phone contacts)
	Animal identification
	Immediate source of the animal being presented
	Inspection result in summary
	Specify if sample is taken (barcode of the sample linked to the animal identification)
Laboratory	Sample identification number
	Tests done (antibiotic residues, brucellosis)

Establishment of teams and facilities for data collection

Initial visits were made to the target areas to train enumerators and refurbish animal holding facilities in all the markets selected for the study. Stakeholder workshops were convened at the same time to inform market actors on the objectives and duration of the study and how they were expected to participate in the study. Participants of these workshops also assisted in defining the trade routes to be considered for the study. The enumerators were responsible for applying the animal identification devices and filling in the data collection forms. They were also expected to contribute to informing market actors about the study. The enumerators and research team met weekly to review field experiences and suggest options to address the challenges encountered. Identification of markets[2] to include in the study was based on a number of factors including catchment areas, volumes of livestock traded, accessibility and possible cross-border linkages.

Numbering system used for animal identification

The numbering system used on the ear tags had four components. The first was a single letter that identified the country where an animal came from (Kenya or Tanzania), the second was a two-letter code which indicated the county or district, the third was a two-letter code which represented the primary market where tagging was done and the fourth was a four-digit serial number. The identification number KNRKK0001, for example, indicated that a tagged animal was from Narok County (NR) in Kenya (K) and was the first animal to be tagged at Kilgoris market (KK). Similarly, TNGRS0080 was an animal from Ngorongoro district (NGR) in Tanzania (T), tagged at the Soit Sambu livestock market and was number 80. Back tags were also used but these were supplied with pre-printed numbers that did not conform to this numbering system. There was an attempt to include traditional identification methods such as animal painting but this failed because traders felt that this would interfere with their usual marketing practices.

Animal identification

Animal tagging (using ear tags and back tags) was done at the primary markets as the animals were brought in for sale. Animals were randomly selected and assigned a number, and their characteristics as well as those of their owners recorded at both entry and exit from the market. Data collected at the point of exit from the market helped to establish changes in ownership and the next destinations of the animals. The total number of animals in the market on the day of sampling was also determined done by counting the animals as they entered the market, when they were already in the sale yard or when they exited the market.

[2] Primary markets: Kilgoris, Lolgorian, Oloolaimutia, Olposimoru and Soit Sambu. Secondary markets: Chebunyo, Ewaso Ngiro, Mulot, Narosura, Ngoosuani, Ntulele and Suswa. Tertiary markets: Dagoretti (Nairobi) and Ewaso Ngiro (Narok).

Data collected at each market were uploaded to the database at the end of each day so that records of each recruited animal were available online by the time the animals reached the secondary and tertiary markets. Data collected at the slaughterhouses on ante mortem and post mortem examinations were also uploaded to the database and merged with initial data collected in the markets.

Focus group discussions and questionnaire surveys
Focus group discussions and questionnaire surveys involving farmers, traders, intermediaries and transporters were conducted immediately after the pilot study. These aimed to collect information on levels of understanding, experiences and perceptions on livestock identification and traceability. The questionnaire surveys included questions on livestock marketing and perceptions on the different identification methods used. Data collected from these activities were analysed using descriptive statistics.

Local stakeholder workshops
A local stakeholder workshop was held on 2–3 September 2014 in Narok, Kenya to review the LITS study protocols and identify market chains to be used in the study. A similar stakeholder workshop was held in Loliondo, Tanzania on 6 November 2014 to introduce LITS activities for northern Tanzania. Veterinarians from local and national headquarters and traders attended both workshops. The workshop participants developed a timeline of activities including a plan for sensitization visits.

Ethical approval
Ethical approval for this study was obtained from ILRI's Institutional Research Ethics Committee. All farmers, traders and market leaders who took part in the study had to provide informed (verbal) consent before being engaged.

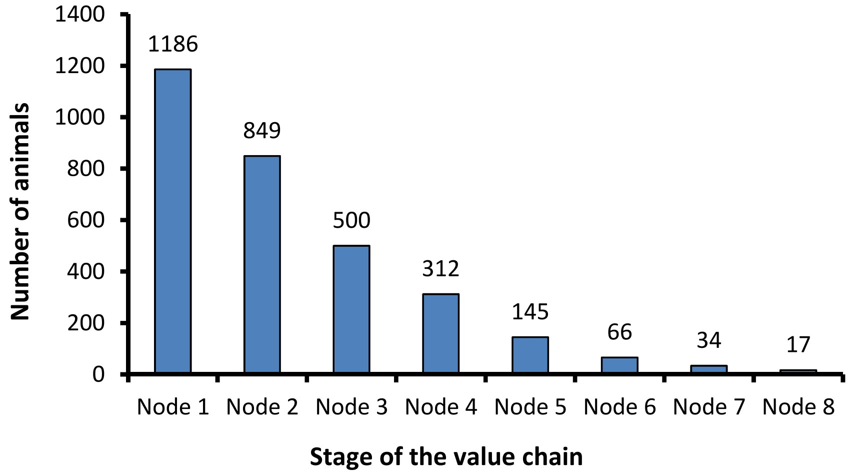
2.4.1.2. Results

Animals tagged
A total of 3114 records from 1186 cattle were captured in the LITS database. Eighty-three per cent (n = 983) of the animals were tagged while entering the primary market while the rest were traced while leaving these markets. The number of times an animal was traced along the value chain varied, as some were taken directly for slaughter after leaving the primary market while others were transferred from one market to another, with the maximum number of times an animal was transferred being eight. The number of animals traced at each stage (assumed to represent a node in the value chain) is shown in Figure 5.

Data collected at the primary market were critical in identifying the sources of the animals entering the market chain. Up to 32.72% (n = 388) of the animals could be traced back to their villages of origin, 39.04% (n = 463) could be traced to other markets in Kenya, 10.37% (n = 123) could be traced to other markets in Tanzania while the sources of the remaining 17.87% could not be identified. This implies that increasing the efficiency of tagging the animals at the primary markets could enable the system capture more accurate information on the identities of the villages from where animals are sourced.

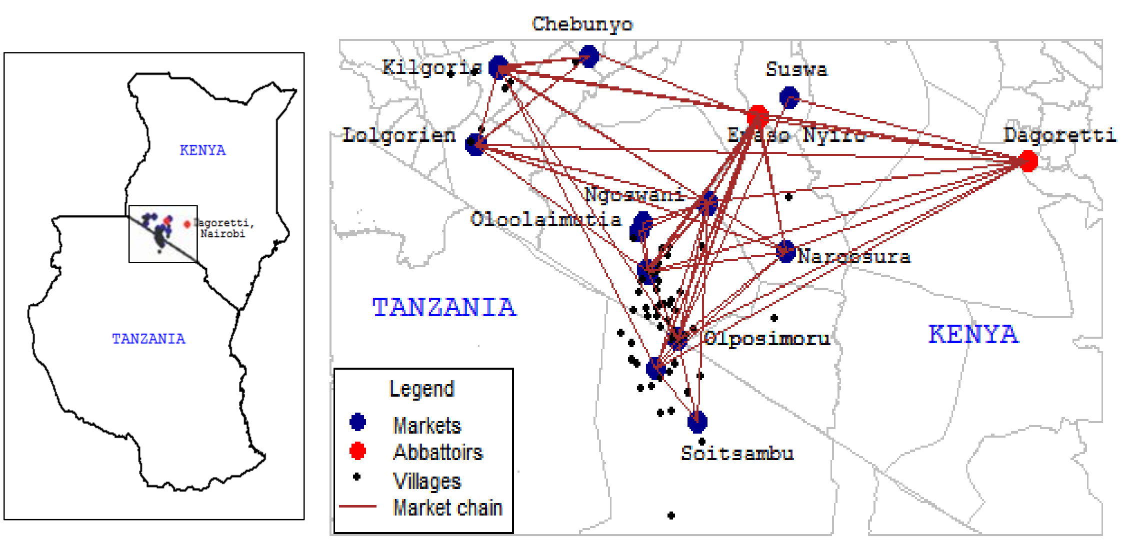
Of the animals tagged in the primary markets, males constituted a slightly higher proportion (57.76%, n = 685) than females and higher proportion of male animals were traced at subsequent stages of the chain such that at node 5, 61.85% of the animals were male. With regard to age, 63.33% (n = 755) of the animals tagged at the primary markets were adults, with the rest being weaners or calves. Similarly, more adults were traced at subsequent nodes of the chain such that at node 5, 72.41% of the animals were adults.

Figure 5: Frequency distribution of the number of animals recorded in the LITS database.



Mapping of value chains
Tracks connecting all the nodes where animals were identified and their records taken were produced in R software (Figure 6). For most of the animals, these tracks represented a uni-directional movement from the villages through the primary markets to the slaughterhouses in either Narok or Nairobi. A few of them, however, had reverse movements from the markets back to the villages or to markets in Tanzania. A few of the animals were lost to follow up.

Figure 6: Tracks connecting the markets and slaughterhouses where data from ear tagged animals were recorded.



Characteristics of value chain actors based on questionnaire surveys
A total of 275 people were interviewed following the completion of the study; these were farmers (n = 36), traders (n = 162), intermediaries (n = 34), transporters (n = 13) and animal trekkers (n = 30). Most of them traded cattle only (n = 211, 76.45%) while 33 (11.96%) traded in cattle and goats, 22 (7.97%) traded in cattle and sheep and 10 (3.62%) traded in other livestock species including donkeys and chicken. With regard to gender, almost all of them were male (n = 274; 99.28%). Their average age was 9.16 years, with a 95% confidence interval of 8.23 and 10.08 years. A large majority of them (n = 194; 70.29%) participated in the pilot study. When asked about what they disliked about their involvement in the study, a few of them indicated that questions asked were too many, repetitive and time consuming.

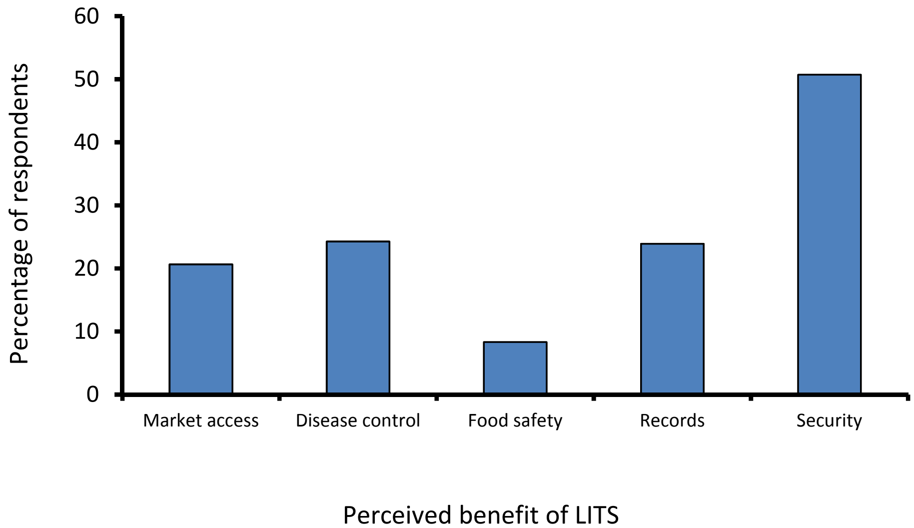
Perceived benefits of LITS

Respondents were asked what they perceived were the benefits of LITS. Most of them indicated that LITS would protect their animals against theft (Figure 7). Other perceived benefits were improvements in disease control, livestock records, market access and food safety. The following were identified as the commonly used livestock identification methods (in decreasing order of frequency): colour of animal, ear notching, hot-iron branding, mud, paints, ear tags and names.

Removal of tags

A small number (14/194) of traders who participated in the study acknowledged removing tags that had been applied on their animals because they feared that buyers would avoid purchasing tagged animals based on a false impression that such animals had been stolen or purchased for a specific purpose. Methods used to remove the tags included cutting with knives, scratching, tearing or covering with mud.

Figure 7: Perceived benefits of LITS among market actors in livestock value chains in the Tanzania–Kenya pilot study.



Factors influencing the use of animal identification methods

Table 5 ranks animal identification methods—hot-iron branding, ear tags, paint, back tags and their combinations—based on socio-economic factors: acceptability, affordability, ease of use and durability. This ranking is based on the percentage of respondents that considered a given factor as being important in the choice of an identification method to use. Generally, hot-iron branding and a combination of ear tags and hot-iron branding had favourable responses across all the socio-economic factors. Considering individual factors, hot-iron branding was ranked highest with regard to durability while ear tags were ranked highest on affordability compared to the other factors.

Livestock marketing challenges

The respondents were asked to state the challenges they encountered in livestock marketing. The main marketing challenges mentioned, in decreasing order of frequency, were:

- inadequate infrastructure (n = 60; 21.74%), including lack of perimeter fences, water and toilets
- low sales and market fluctuations (n = 45; 16.30%)
- high taxes with poor services (n = 30; 10.87%)
- poor market access due to long distance or poor roads (n = 26; 9.42%)
- animal losses, specifically through theft and insecurity (n = 20; 7.25%)

Other challenges mentioned were high competition, congestion, exploitation, low sales, price fluctuations and unfavourable time set aside for livestock marketing.

Table 5: Factors influencing the use of livestock identification methods

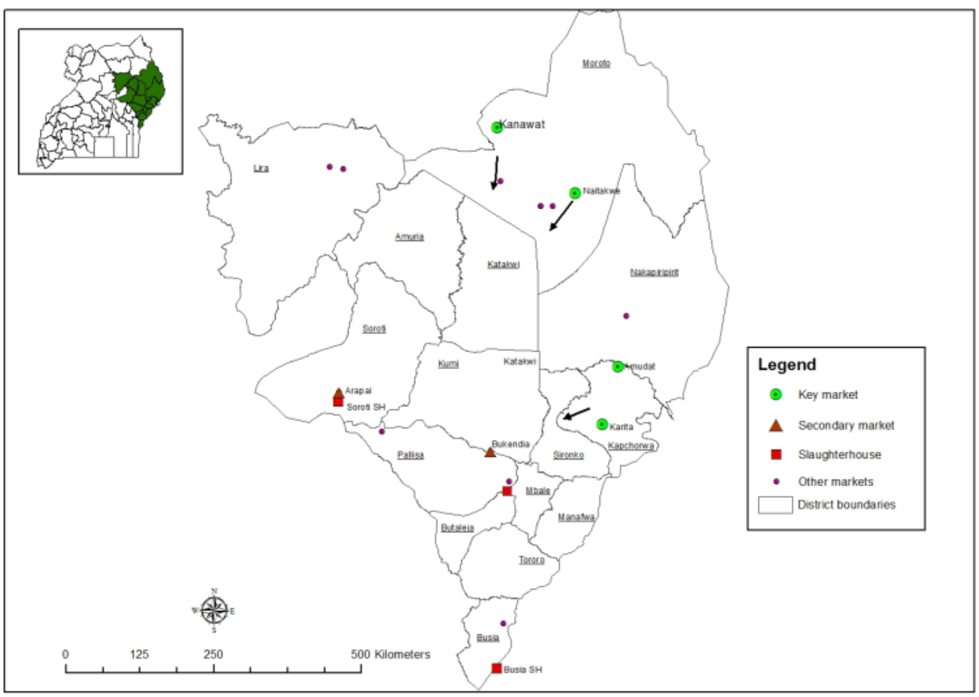
Identification method	Acceptability		Affordability		Ease of use		Durability	
	n	%	n	%	n	%	n	%
Hot-iron branding	142	51.45	130	47.10	121	43.84	184	66.67
Ear tags	29	10.51	39	14.13	29	10.51	11	3.98
Paint	15	5.43	27	9.78	45	16.3	4	1.45
Back tags	3	1.09	3	1.09	1	0.36	2	0.72
Ear tags + hot-iron branding	48	17.39	44	15.94	39	14.13	51	18.48
Paint + hot-iron branding	10	3.62	7	2.54	8	2.90	-	-
Ear tags + hot-iron branding + paint	4	1.45	3	1.08	7	2.54	1	0.36
Ear tags + paint	1	0.36	1	0.36	2	0.72	1	0.36
Missing records	24	8.70	22	7.97	24	8.70	22	7.97

2.4.2. Karamoja-Soroti-Busia value chain

2.4.2.1. Methods

Field visits were made to map out the study sites in Uganda (Figure 8). The following sites were selected for the pilot study: primary markets in Amudat, Kanawat and Naitakwe; secondary markets in Arapai, Bukedea and Soroti and slaughterhouses in Busia, Mbale and Soroti. Check points in Iriiri and Namalu were also identified.

Figure 8: Map of identified markets and slaughterhouses for the Uganda pilot study.



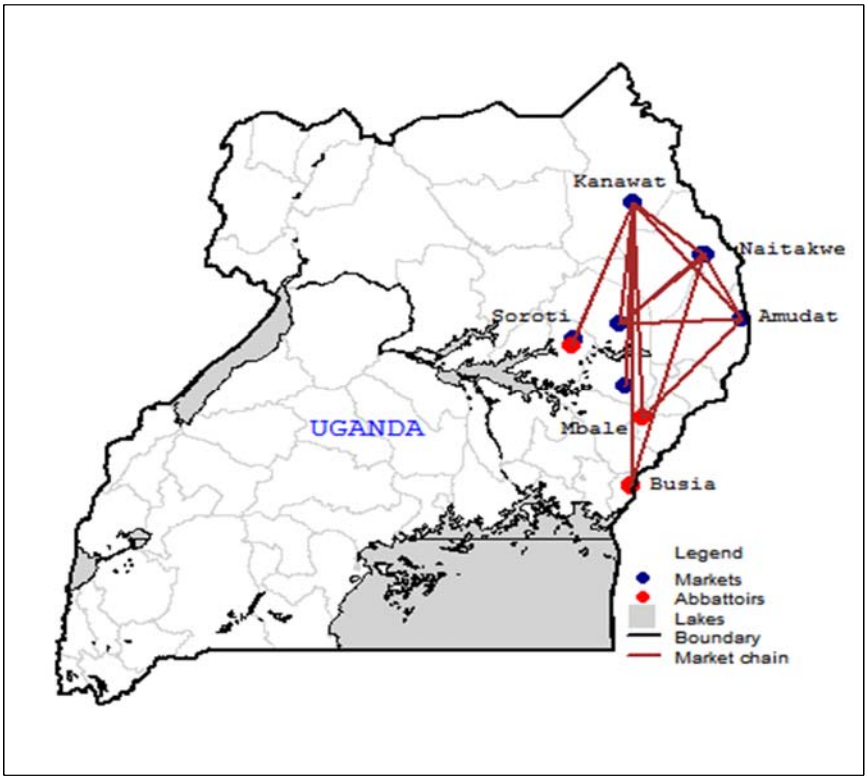
Methods for animal identification and data collection (including questionnaire surveys) were similar to those described under the Tanzania–Kenya pilot study (Section 2.4.1.1.).

2.4.2.2. Results

Animals tagged

A total of 1256 records from 607 cattle were captured in the database. The market chain mapped from these records is shown in Figure 9.

Figure 9: Map of livestock markets and market chains covered by the pilot study.



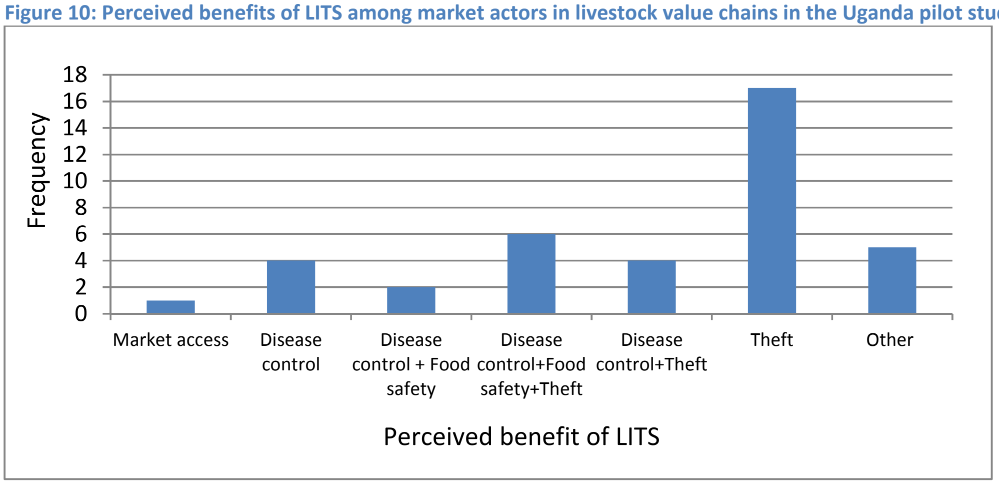
Characteristics of value chain actors

A total of 39 people were interviewed in Karamoja. These were livestock traders (22), producers (5), brokers (4) and others who had multiple sources of livelihoods including livestock production, trade and transportation. Responses were obtained from Amudat (12), Bukedea (10), Kanawat (9) and Naitakwe (8) markets. All the respondents were males and their mean age was 39.23 (standard error 1.42).

Perceived benefits of LITS

A large percentage of the respondents (n = 17; 43%) said that LITS would help them prevent livestock theft (Figure 10). Other perceived benefits mentioned were improved disease control, food safety and market access. Some of these responses were presented as composite answers with one or more benefits being combined.

Figure 10: Perceived benefits of LITS among market actors in livestock value chains in the Uganda pilot study.



Animal identification methods in use
The main animal identification measures in use at the time of survey were animal characteristics (mainly colour), ear tags, ear notching and hot-iron branding. About 30% of the respondents (12/39) said they removed the ear tags used in the project mainly because they feared that sellers would reject tagged animals.

Factors influencing the use of livestock identification methods
Table 6 shows the number and percentage of respondents who considered specific factors (accessibility, affordability, ease of use and durability) as being important in influencing their choice of livestock identification method. Ear tags were ranked highest with regards to all four factors. Paint was ranked second with respect to affordability and ease of use.

Table 6: Factors influencing the use of livestock identification methods

Identification method	Acceptability		Affordability		Ease of use		Durability	
	n	%	n	%	n	%	n	%
Hot-iron branding	9	23.08	8	20.51	6	15.38	12	30.77
Ear tags	17	43.59	16	41.03	21	53.85	16	41.03
Paint	6	15.38	10	25.64	10	25.64	-	
Ear tags + hot-iron branding	3	7.69	4	10.26	2	5.13	5	12.82
Paint + hot-iron branding	-		-		-		-	
Ear tags + hot-iron branding + paint	-		-		-		-	
Ear tags + paint	4	10.26	-		-		-	
Bolus	-		-		-		2	
Missing records	-		1		-		2	5.13
Others	-		-		-		2	

Livestock marketing challenges
The respondents identified the following marketing challenges:

- Poor infrastructure (cited by 12 of 39 respondents), specifically, lack of fences, loading ramps, offices, restaurants, toilets and slaughter slabs
- High livestock prices
- High market charges including taxes
- Theft of livestock and pick pocketing

2.4.3. Conclusions from the two pilot studies

Awareness campaigns involving all market actors (producers, traders, intermediaries, butchers and market officials) should be initiated to improve knowledge of LITS and its associated opportunities and challenges, and define the roles of each actor in the market chain. For example, traders or intermediaries who collect animals from the production units (and hence prevent producers from travelling to the markets) should be encouraged to record the sources of the animals they purchase to enhance the accuracy of information provided at the primary markets.

Results from the questionnaire surveys show that ear tags are highly preferred by most respondents while hot-iron branding and ear notching are frequently used. We recommend the use of ear tags for individual identification and hot-iron branding and ear notching for group identification.

There have been several discussions on the implications of tagging animals at the farm/production units versus primary markets on the depth of the traceability system to be realized. The data show that tagging animals at the primary market can still allow animals to be traced back to their villages of origin (i.e. it can still provide a robust system). Measures to improve the accuracy of information obtained from such a system include defining epidemiological units that producers, intermediaries and traders can identify easily when asked, and collecting additional information at the time of tagging to be used for cross-validation.

In some areas in the region, animal identification is done at the production units to support animal management and disease control (e.g. use of ear tags to identify animals that have been vaccinated against East Coast fever) or deter insecurity associated with cattle theft (e.g. in parts of northwestern Kenya, northeastern Uganda and South Sudan); these activities should be integrated with LIT interventions. Veterinary departments should strengthen collaboration between institutions that are implementing such activities.

LIT projects should make use of available mobile phone networks for data collection and storage. This will enhance the efficiency of the system and enable a faster turnaround time when a trace-back or trace-forward needs to be made.

The existing livestock marketing infrastructure is not conducive for the implementation of effective LITS in the region. Key interventions that are urgently needed are to:

- develop policies on LIT so that producers, intermediaries, traders and market officials understand their respective responsibilities
- develop a LIT governance plan that clearly states the required institutions and processes and institutionalizes LIT in private and public sectors
- renovate crushes and fences in the markets to restrain animals during tagging and then move them along specific channels where their identification numbers and other characteristics can be determined.

2.5. Risk assessment: Borena-Adama value chain in Ethiopia

In the first half of 2016, the study assessed the risk of release of foot and mouth disease virus (FMDv) and *Mycoplasma mycoides* subsp. *mycoides* Small Colony (Mmm SC), the causative agent of CBPP, from Ethiopia through the export of live animals (cattle) and beef via the Borena-Adama value chain. This value chain handles a significant quantity of live animals and beef for export and hence many interventions (e.g. development of LIT infrastructure and refurbishment of markets) have been put in place to support this trade. The risk assessment was aimed at strengthening these interventions by identifying additional measures required to control trade-sensitive animal diseases.

2.5.1. Methods

2.5.1.1. Risk questions and pathways

The study was designed during a workshop involving technical personnel from local and international institutions working on animal health and livestock trade. The scope of the assessment was defined and risk questions and risk pathways were formulated. The risk questions were:

- What is the likelihood of cattle sourced from the Borena-Adama value chain being exported from Ethiopia with FMDv and Mmm SC?
- What is the likelihood of beef products from cattle sourced from the Borena-Adama value chain being exported from Ethiopia with FMDv?

Two risk pathways (one for each risk question) were identified based on the structure of the value chain and the type of premises and actors involved in livestock marketing. The pathways defined a series of events that would result in the hazard being exported from Ethiopia, starting from selection of an animal for sale at the community level in Borena to inspections at the border posts. Figure 11 summarizes the pathway for the risk of release of FMDv and Mmm SC via live animal export while Figure 12 summarizes the pathway for the risk of release of FMDv via beef. The latter pathway assumes that the risk pathway from production sites to the feedlots is similar to that of the first risk pathway. Descriptions of the probabilities for each step of the risk pathway and data required to estimate their values are given in Table 7 (live animal risk pathway) and Table 8 (beef risk pathway).

Figure 11: Summary of the risk of release pathway for FMDv and Mmm SC through export of live animals from Ethiopia.

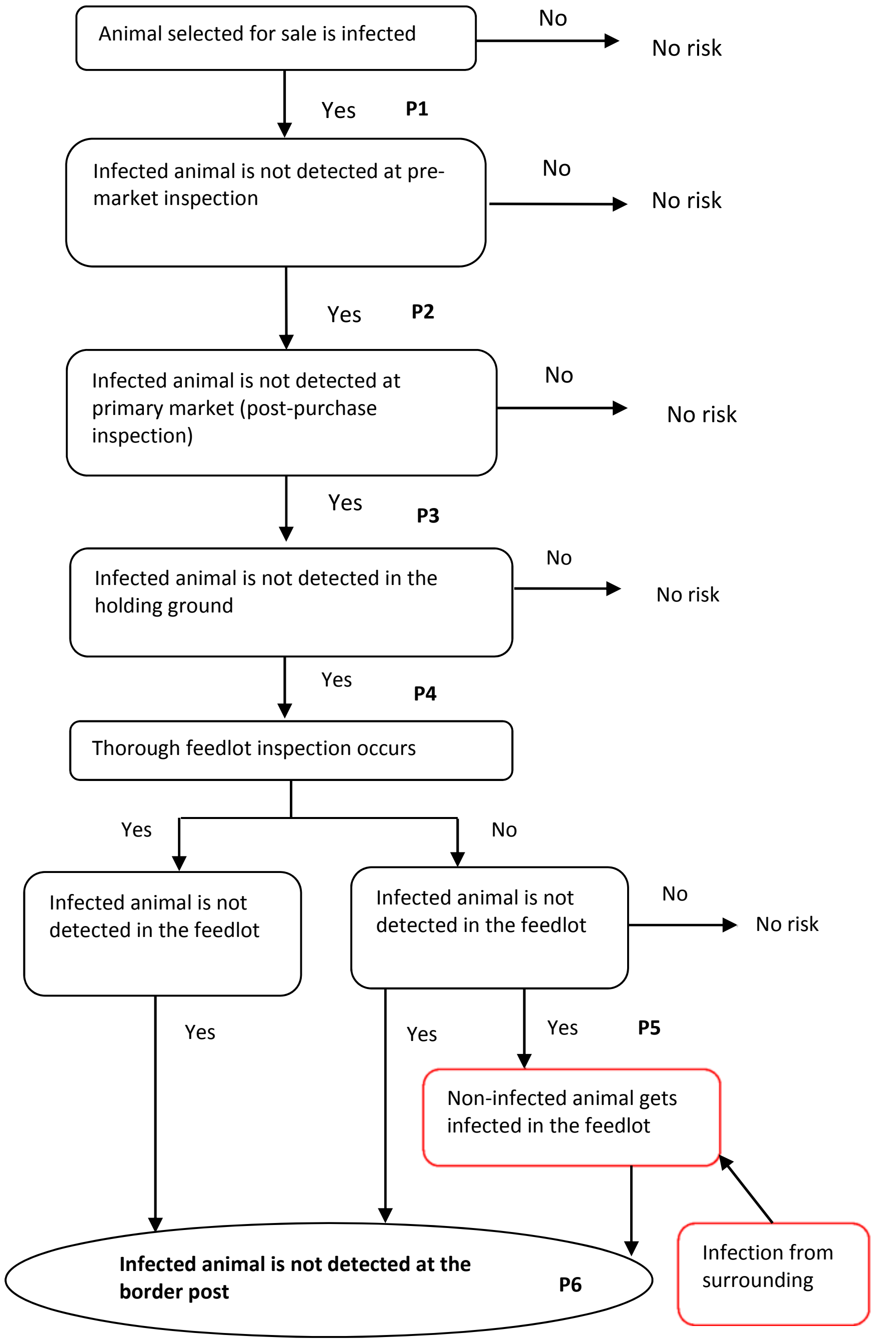
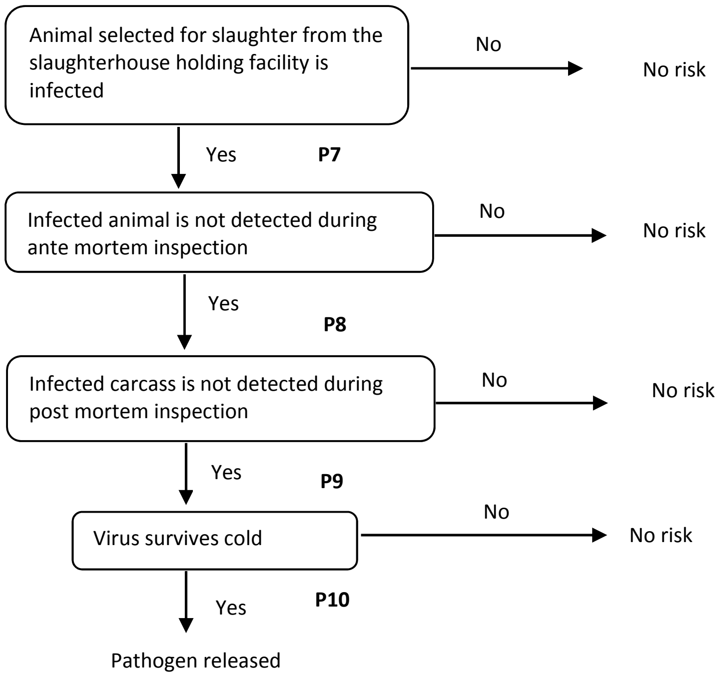


Figure 12: Summary of the additional events considered for the risk of release of FMDv through beef exported from Ethiopia.



2.5.1.2. *Risk estimation*

The qualitative risk assessment methodology defined by the World Organisation for Animal Health (OIE 2004) was used for risk estimation. Up to six probability levels were considered: negligible, very low, low, medium, high and very high. Each risk estimate was associated with uncertainty and variability values which were also defined qualitatively. As it was not always possible to differentiate variability from uncertainty, both parameters were combined and presented as uncertainty.

The analysis considered two scenarios: one estimated the risk of release of the hazards under the existing market infrastructure (with no LITS) and the other considered a hypothetical scenario that assumed functioning LIT infrastructure with pre- and post-market inspections of animals and pre-feedlot holding grounds where animals would be confined and monitored for clinical syndromes for at least three days. Pre- and post-market inspections would be done by qualified animal health workers outside the markets and only those animals found to be healthy would be certified for sale. Animals manifesting signs such as lameness, salivation, abnormal discharges, coughing and other clinical signs would be discarded. This inspection would be clinical and so it would not be able to detect sub-clinical infections. Risk estimates for each scenario and pathway were generated by combining individual probabilities outlined in Table 7 and Table 8 as described by Zepeda-Sein (1998).

Table 7: Data used for estimating values of the probabilities identified in the live animal risk pathway

Risk pathway steps	Data required	Sources
P1: Probability that an animal selected for sale is infected with FMDv or Mmm SC	Prevalence, incidence or surveillance records Disease prevention and control practices at the community level Vaccination practices: vaccine type, source and production capacity	Published and unpublished reports Ministry of Agriculture and National Veterinary Institute reports Laboratory reports (Regional Veterinary Laboratory; National Animal Health and Diagnostic Centre) Woreda Department of Veterinary Services (DVS) reports
P2: Probability that an infected animal is not detected at pre-market inspection	Inspection procedures: methods; individual versus group inspection; skill and number of officers involved Frequency of market days and volume of animals traded Natural history of the disease	Standard Operating Procedure (SOP) for inspection Inspection records from the DVS and local offices LIT data
P3: Probability that an infected animal is not detected during inspection at the primary market after purchase	Inspection procedures: methods; individual versus group inspection; skill and number of officers involved Frequency of market days and volume of animals traded Natural history of the disease	SOP for inspection Inspection records from the DVS and local offices LIT data
P4: Probability that an infected animal is not detected in the holding grounds	Inspection procedures: methods; individual versus group inspection; skill and number of officers involved Natural history of the disease	SOP for inspection Inspection records from the DVS and local offices LIT data
P5: Probability that an infected animal is not detected in the feedlot	Inspection procedures: methods; individual versus group inspection; skill and number of officers involved Disease control measures Methods used for screening animals: type and sensitivity of tests used Biosecurity in the feedlots Compliance with the SOP by officers	Feedlot records: disease outbreak reports and treatment Inspection records from the DVS and local offices
P6: Probability that infected animal is not detected at the border post	Inspection procedures: methods; individual versus group inspection; skill and number of officers involved Methods used for screening animals: type and sensitivity of tests used	Border post records Inspection records

Table 8. Data used for estimating values of the probabilities in beef risk pathway

Risk pathway steps	Data required	Sources
P7: Probability that an animal selected for slaughter from the slaughterhouse holding facility is infected	Inspection procedures: methods; individual versus group inspection; skill and number of officers involved Natural history of the disease	SOP for inspection Inspection records from the slaughterhouse
P8: Probability that an infected animal is not detected during ante mortem inspection	Inspection procedures: methods; individual versus group inspection; skill and number of officers involved	Slaughterhouse records
P9: Probability that an infected carcass is not detected during post mortem inspection	Inspection procedures: methods; individual versus group inspection; skill and number of officers involved	Slaughterhouse records
P10: Probability that the virus survives cold storage	Inspection procedures: methods; individual versus group inspection; skill and number of officers involved	SOP for cold storage Published information on stability of the virus in low temperatures

2.5.2. Results and discussion

2.5.2.1. Live animals risk pathway for FMDv

Probability that an animal selected for sale is infected with FMDv (P1)

Cross-sectional surveys conducted in Borena and Guji indicated that the mean seroprevalence of FMDv was 24.6% (Mekonen et al. 2011), with a much higher seroprevalence in Borena (53.6%) than in Guji (10.1%). Similar surveys conducted in Borena reported animal-level and herd-level seroprevalences of 23.0% and 58.6%, respectively (Bayissa et al. 2011). Other surveys found FMDv seroprevalences of 9.5% (Megersa et al. 2009), 12.1% (Gelaye et al. 2009), 14.5% (Alemayehu et al. 2014) and 10.5% (Ayelet et al. 2012). Most of these surveys used 3ABC enzyme-linked immunosorbent assay (ELISA) test which is capable of differentiating vaccine-induced antibodies from those from natural infection. These estimates represent a median of 13.1% and 10th and 90th percentiles of 9.4% and 24.6%, respectively. The incidence of outbreaks is thought to be higher during the drier months of the year when animals congregate at a few grazing and watering points (Rufael et al. 2008).

The area does not have an effective FMD vaccination program. According to the Zonal Agricultural Bureau, Borena alone has about 1.8 million cattle, 1.3 million goats and 664,000 sheep. These animals should be vaccinated at least twice a year yet the National Veterinary Institute can produce only up to 500,000 doses of FMD vaccine per year. Moreover, most of the animals reared in the area are of indigenous livestock breeds that can sustain FMDv transmission for an extended period of time before manifesting tell-tale clinical signs. This implies that the reproductive number of the disease would be high given (i) the extended infectious period associated with the indigenous breeds (although the ability of carriers to transmit the virus is not clearly known [Moonen et al. 2004]) and (ii) frequent movements which increase contact between multiple susceptible herds or flocks. There is a high likelihood of sub-clinically infected animals being selected for sale in the primary markets. However, given high level of knowledge on the disease among producers and the importance attached to the disease by other value chain actors such as feedlot and slaughterhouse operators, the likelihood of an infected animal being selected for sale is thought to be medium and the level of uncertainty is low.

Probability that an infected animal is not detected at pre-market inspection (P2)

Currently, there is no pre-market inspection of animals and hence this step was not included in the analysis under the existing marketing scenario. During reconnaissance visits to Dubluk and other markets in the Borena region, it was found that producers and intermediaries traded outside the market to avoid paying market fees. After this, traders drove purchased animals into the market enclosures for inspection in order to obtain a heath certificate required for transportation. Veterinary officers are, therefore, not given any chance to conduct pre-market inspection and hence P2 would be equivalent to P1 given the absence of any intermediate intervention before an animal is purchased by traders.

Under the LITS scenario, however, the likelihood of an infected animal passing through pre-market inspection without being detected is expected to be low especially if the producers will be involved and regarded as important stakeholders in the livestock trade. The uncertainty is considered to be low although this is debatable since the incubation period of FMDv among the local livestock breeds, and their ability to maintain infection sub-clinically, is variable. Other risk assessments conducted for transboundary animal diseases assume that there is an 80–90% chance that infected animals are identified by animal health officers during clinical inspection (Knight-Jones et al. 2014; Woube et al. 2015). The 10–20% risk of non-detection is assumed to be equivalent to the low risk estimate used in this analysis.

Probability that an infected animal is not detected during inspection at the primary market after purchase (P3)

Currently, the post-purchase screening of animals in primary markets is limited and only implemented to meet conditions for the issuance of transport permits. There is a high risk of infected animals not being detected here, although feedlot and slaughterhouse operators often look for healthy animals in good body condition to prevent introducing trade-sensitive diseases onto their premises. Under the current scenario, the risk of an infected animal not being detected at the post-purchase inspection at the primary market is considered to be medium with low uncertainty.

For the second scenario (with LITS program), animal health officers will be expected to be more thorough in their inspection. This is because it will be possible to identify the premises that any animal found infected higher up the chain will have passed through. In this case, the likelihood of an infected animal passing through post-purchase inspection at the primary market without being detected will be low with low uncertainty.

Probability that an infected animal is not detected in the holding grounds (P4)

This step was ignored in the risk assessment under the first scenario because there are currently no holding grounds currently in the value chain. It is assumed that the level of risk expected at the post-purchase inspection will be similar to that expected at the point of entry of the animal into the feedlots. Animals are often transported from the primary markets to the feedlots in trucks over a period of not more than 24 hours. Local transmission of the pathogens between animals while in transit is assumed to be negligible.

When the LIT program commences, market livestock will be kept under observation in holding grounds for at least three days before being introduced into the feedlots or export slaughterhouses. While in the holding grounds, routine veterinary care will be provided, including isolation and removal of sick animals. However, the three-day observation period in the holding grounds will be insufficient to allow animals that are in the early stages of exposure to either FMDv or Mmm SC to develop clear clinical signs. Chances of an infected animal passing through the holding grounds without being detected will be low with low uncertainty.

Probability that an infected animal is not detected in the feedlot (P5)

On admission into the feedlots, animals are often drenched, dipped and vaccinated against FMD serotypes A, O and SAT2, lumpy skin disease and CBPP. FMD vaccination using vaccines that adequately match the challenge strains confers a high degree of protection.

There are no records or publications showing the incidence of FMD in the feedlots. Available publications give FMDv seroprevalence estimates but it is not clear whether these represent new infections in the facilities or old exposures that occurred before the animals were introduced into the feedlots. Local livestock (owned by the communities that live close to the feedlots) grazed around these facilities, increasing the chances of wind-borne FMDv entering the feedlots.

Given that animals are kept in the feedlots for at least 3–4 months, it is likely that those brought in with active infections would recover by the time this period elapses (the pathogen's mean infectious period is seven days). In addition, animals are often screened for FMD using 3ABC ELISA before leaving the feedlot to ascertain their infection status. In this case, the likelihood of infected animals not being detected at the time of exit from the feedlot was considered to be very low with low uncertainty.

Probability that an infected animal is not detected at the border post (P6)

At the border post, live animals are not subjected to any formal screening unless there is evidence of malpractice or there are reports of disease outbreak. It is assumed that the level of risk expected at this point of the risk pathway would be equivalent to that expected at the point of exit from the feedlot.

2.5.2.2. Beef risk pathway for FMDv

Probability that an animal selected for slaughter from the feedlot or slaughterhouse holding facility is infected (P7)

A majority of the animals slaughtered in the export slaughterhouses are obtained from feedlots either owned by the export slaughterhouses or independently operated by other actors. It is, therefore, assumed that the probability of an infected animal being selected for slaughter is equivalent to that predicted for the risk of an animal exiting a feedlot with FMDv infection (the probability that an infected animal is not detected in the feedlot [P5]). This estimate captures all the risk steps that precede this point, starting from the selection of an animal for sale at the production point to the point of exit at the feedlot.

Probability that an infected animal is not detected during ante mortem inspection (P8)

Export slaughterhouses maintain high biosecurity standards in their premises and have reliable procedures for ante mortem inspection. The facilities visited during the survey had veterinary staff who conducted routine inspection of animals and maintained various records including those of diseases that occur in the feedlot. Examinations for FMD focused on the feet and mouth to enhance the chances of finding infections. Interviews conducted with some slaughterhouse workers in Adama indicated that 1–2% of animals selected for slaughter are often rejected, returned to the slaughterhouse holding facility or culled if severe injuries are noted. Furthermore, animals selected for slaughter are kept under observation in the lairages for 12–18 hours without food and water. Chances of an infected animal not being detected during ante mortem inspection are, therefore, low with low uncertainty. However, no laboratory screening is done to support the clinical examinations.

Probability that an infected carcass is not detected during post mortem inspection (P9)

Post mortem inspections seek to identify lesions that can signal FMD exposure, for example, vesicles in the feet and mouth. During slaughter, a system for matching the skin, carcass and other tissues of the animal is often used to allow efficient post mortem inspection. The risk of an infected carcass not being detected during post mortem inspection is low and the level of uncertainty is low. This is because no laboratory verifications are made and sub-clinical infections would not be detected at this point.

Probability that the virus survives cold storage (P10)

The slaughterhouses visited during the survey follow the standard procedures for curing meat intended for export. After slaughter, meat is cured at chilling temperatures for at least 24 hours to allow a drop in pH, hence reduced FMDv survival. A drop in pH from 7 to 5.5 follows the formation of 60 to 80 millimoles of lactic acid per kilogram of muscle tissue, depending on muscle tissue and animal species (Paton et al. 2010). The build-up of lactic acid causes unfavourable conditions for the survival of FMDv, especially if the pH levels are maintained below 6 for at least 48 hours at 4°C (Henderson and Brooksby 1948). Heads, pharynx, superficial lymph nodes, bones and large blood vessels are often removed to reduce the risk of FMD in deboned meat products. This is because in some of these tissues, the pH does not drop as much compared to that in the carcass or meat cuts. However, the virus can survive in meat in blood clots or from contamination. However, the export slaughterhouses visited had good practices for limiting contamination, e.g. moving the carcasses forwards and away from the dirty zones on conveyor belts as they are being processed. When all these measures and biological changes are considered, the risk of a carcass maintaining the virus is very low and the level of uncertainty is low. Deboned meat is usually chilled at -18°C but this practice alone cannot guarantee safety. For bovine meat, the virus has been recovered from meat stored at -9°C to -13°C after 76 days (Henderson and Brooksby 1948) and so chilling temperatures have to be lower than these to ensure that the virus is eliminated. The chance that the virus can survive the cold chain is very low with low uncertainty.

Summary: Risk of release of FMDv

Table 9 summarizes the risk estimates for all the nodes of the live animal risk pathway under both scenarios (without and with LITS) while Table 10 provides the same parameters for the beef risk pathway. The overall risk estimates are also provided. The LITS would introduce at least three additional nodes in the live animal risk pathway, i.e. pre-market, post-market and holding ground inspections. The additional nodes would increase the number of check points and improve inspection standards, leading to reduction in the risk of release of FMDv from very low (with negligible uncertainty) to negligible (with negligible uncertainty). For the beef risk pathway, both with and without LITS, there is negligible risk of infected meat being exported from the country because of the stringent measures employed by the export slaughterhouses that do not allow for contamination and discharge of infected carcasses. Furthermore, the pH changes that occur in meat post mortem reduce the chances of FMDv survival.

Table 9: Risk estimates for the nodes in the FMDv risk pathway for live animals and overall estimate from the risk assessment

Probability	Node	Existing scenario		With LITS	
		Risk estimate	Uncertainty	Risk estimate	Uncertainty
P1	Production area	M	L	M	L
P2	Pre-market	na	na	L	L
P3	Post-market	M	L	L	L
P4	Holding ground	na	na	L	L
P5	Feedlot	VL	L	VL	L
P6	Border post	VL	L	VL	L
	Overall risk estimate	VL	N	N	N

M: medium; L: low; VL: very low; N: negligible; na: not applicable

Table 10: Risk estimates for the nodes in the FMDv risk pathway for beef and overall estimate from the risk assessment

Probability	Node	Existing scenario		With LITS	
		Risk estimate	Uncertainty	Risk estimate	Uncertainty
P1	Production area	M	L	M	L
P2	Pre-market	na	na	L	L
P3	Post-market	M	L	L	L
P4	Holding ground	na	na	L	L
P5	Feedlot/slaughterhouse holding	VL	L	VL	L
P8	Ante mortem inspection	L	L	L	L
P9	Post mortem inspection	L	L	L	L
P10	Cold storage in transit/curing	VL	L	VL	L
	Overall risk estimate	N	N	N	N

M: medium; L: low; VL: very low; N: negligible; na: not applicable

2.5.2.3. *Live animals risk pathway for Mmm SC*

Probability that an animal selected for sale is infected with Mmm SC (P1)

CBPP has for a long time been a leading animal health problem in Borena. Its prevalence is thought to be declining in the area due to mass vaccinations and antibiotic treatment by the Department of Veterinary Services and non-governmental organizations (Alemayehu et al. 2015). Surveys conducted in 1995 reported a seroprevalence of 74% (Roger and Yigezu 1995) but more recent surveys by Kassaye and Molla (2012) and Alemayehu et al. (2015) report much lower seroprevalence estimates of 4% and 0.4%, respectively. Data obtained from the DVS on CBPP outbreaks that occurred between 2007 and 2014 indicate median (10th and 90th percentiles) morbidity, mortality and case fatality rates of 0.18 (0.05–2.55), 0.11 (0.01–0.45) and 39.85 (11.90–75.00), respectively. The transmission risk of the disease is often higher during the humid season than the dry season because ultra-violet radiation denatures the causative agent. Given the low prevalence of the disease in the area, the likelihood of selecting an animal infected with Mmm SC is <u>low</u>. There is an appreciable variability in the prevalence estimates obtained, ranging from < 1% to 4%; this represents a <u>medium</u> uncertainty in the estimates.

Probability that an infected animal is not detected at pre-market inspection (P2)

Animals are not subjected to any veterinary inspection before reaching the feedlots (Alemayehu et al. 2015). With LITS in place, the likelihood of an animal infected with Mmm SC not being detected would be <u>low</u> with <u>medium</u> uncertainty. This is because clinical diagnosis of CBPP is difficult; it must be confirmed by serological tests but these will not be routinely applied at the primary markets given the costs and logistics involved.

Moreover, the sensitivity of available tests, such as complement fixation test and cELISA, ranges between 92% and 97% (Woube et al. 2015).

Probability that an infected animal is not detected during inspection at the primary market after purchase (P3)
Currently, there is limited inspection of animals at the primary market and hence the likelihood that an infected animal is not detected here is medium with low uncertainty. Under the LITS, animals will be ear tagged at the primary markets so it will possible for veterinary officials to conduct adequate clinical examination of each animal before exiting the markets. The likelihood of an infected animal exiting the market will, therefore, be low with medium uncertainty.

Probability that an infected animal is not detected in the holding grounds (P4)
This is similar to the probability described under the FMDv pathway.

Probability that an infected animal is not detected in the feedlot (P5)
Atnafie et al. (2015) observed a relatively higher seroprevalence of CBPP in abattoirs (7.8%) and feedlots (5.9%) than that reported in the pastoral areas in Borena described above. CBPP causes lobar pneumonia and in some cases, sequestrae are formed within two weeks of infection making it more difficult for the standard clinical and some diagnostic tests to identify infected animals. Transmission of the disease can also occur via droplets that can be carried by wind up to 200 metres from the source of infection. Animals that graze in the neighbourhoods of the feedlots can, therefore, serve as a source of infection. The likelihood that an infected animal is not detected in the feedlot is, therefore, low with medium uncertainty.

Probability that an infected animal is not detected at the border post (P6)
This is similar to the probability described under the FMDv risk pathway.

Table 11 summarizes risk estimates and the results obtained from the assessment of the Mmm SC live animal risk pathway. Given the local prevalence of CBPP in the source population, the risk pathways analysed give negligible risk of an animal with CBPP being exported from Ethiopia. However, the extra nodes introduced under the LITS would reduce the uncertainty of the risk estimates from low to very low.

Table 11: Risk estimates for the nodes in the Mmm SC risk pathway for live animals and overall estimate from the risk assessment

Probability	Node	Existing scenario		With LITS	
		Risk estimate	Uncertainty	Risk estimate	Uncertainty
P1	Production area	L	M	L	M
P2	Pre-market	na	na	L	M
P3	Post-market	M	L	L	M
P4	Holding ground	na	na	L	VL
P5	Feedlot	VL	L	L	M
P6	Border post	VL	L	VL	L
	Overall	N	L	N	VL

M: medium; L: low; VL: very low; N: negligible; na: not applicable

3. Way forward

The results from the stakeholder workshop, situation analysis and pilot studies have been reviewed and utilized. However, those from the risk assessment have not. Therefore, it is recommended that the results from the risk assessment be reviewed by the local stakeholders in Ethiopia.

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