



(RESEARCH ARTICLE)



A QUALITATIVE RISK ASSESSMENT OF FOOT AND MOUTH DISEASE (FMD) ON SMALLHOLDER LIVESTOCK FARMING IN SIERRA LEONE, THE CASE OF SIX (6) DISTRICTS IN THE NORTHERN AND EASTERN SIERRA LEONE

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ABSTRACT

Foot and Mouth disease (FMD) is a highly infectious, disease of cloven-hoofed animal species, and is caused by Foot-and-mouth disease (FMD) of the genus Aphthovirus and the family Domesticated animals such as cattle, pigs, sheep, goats and water buffalo are susceptible to FMD. Wildlife species may also become infected especially cloven-hoofed species. Taking into account the limited resources of veterinary services for the implementation of animal disease surveillance anywhere and anytime, a qualitative risk assessment study was conducted to identify the areas at risk of introduction, spread and occurrence of the disease, in order to target and put in place precautionary control measures, including targeted surveillance. The risk query of the study was “What is the risk of introduction of FMD into Sierra Leone from neighboring countries, especially Guinea and Liberia as a result of the legal and illegal trade movements. The study was conducted through a purposive sampling strategy in 6 districts in North and North-East Sierra Leone. A total of 240 participants in 24 chiefdoms and 48 communities were recorded. Because of its qualitative attributes, the assessment employed a descriptive design to prompt information on the existing phenomena. A total of 4 chiefdoms were randomly selected in each district, and 2 communities were selected in each chiefdom, with 5 household interviews conducted in each of the selected communities. The study found that the risk of FMD getting into Sierra Leone from Guinea is Low. Communities near the border within Guinea attested to the previous outbreak of FMD in 2018-2019, and since then, they have not witnessed a serious occurrence of the disease. There is a negligible risk of FMD getting into Sierra Leone because of the low movement of animal trade from Liberia, as compared to Guinea, where the majority of the animal movement takes place. The study recommends enhancing farmers' capacity to mitigate FMD risk of introduction and spread along the value chain actors (implementation of good practices, Biosecurity measures.

Keywords: Qualitative, Risk Assessment, Foot and Mouth Disease, Sierra Leone, Trans-Boundary

1 INTRODUCTION

In Sierra Leone, FMD is one of the priority diseases monitored by the Animal Disease Surveillance and Response system implemented (FAO, 2013). The disease is characterized by high fever, loss of appetite, salivation, and vesicular flare-ups on the feet, mouth, and teats (FAO, 2013). The harshness of clinical signs varies with the strain of virus, exposure dose, age, and breed of animals, host species, and immunity of the animal. Mortality from a multifocal myocarditis is most commonly seen in young animals in susceptible species (Anderson, 2010). The highly contagious nature of FMD and the related efficiency losses make it a primary animal health concern worldwide. According to Anderson, FMD risks either through production losses caused directly by the disease or the cost for FMD prevention and control. Due to its severe impact on trade in animals and animal products, it is one of the most important transboundary animal Disease (TAD) in the international trade context (Anderson, 2010). The Sierra Leone (SL) livestock sector represents a promising economic opportunity for poverty reduction, growth, diversification, and income generation, especially for smallholder farmers as well as a means of providing food safety and nutrition benefits (UNDP, 2010). However, the sector's contribution to GDP has stagnated at 3% in recent years. Livestock production is low, driven largely by traditional production practices and low yielding local animal breeds, and troubled by poor animal nutrition, inadequate production facilities, and ineffective management practices (FAO, 2013). Only 29.4% in rural households engage in livestock production, and livestock is the main source of livelihoods for only 5.9% of rural households (WFP, 2015) (FAO, 2013). In addition, the livestock sector was devastated by EVD outbreak in 2014 as numbers declined across species; goats, - 28.9%, sheep - 43% and chickens - 28.6%, exposing people to greater food and nutrition insecurity. The Sierra Leone livestock sector is inundated by persistent structural inadequacies (World Bank, 2012)

For this purpose, a qualitative risk assessment permits the identification of areas at high risk of introduction, spread and occurrence of emerging and re-emerging diseases and helps to target and put in place precautionary control measures including targeted surveillance for early detection of national priority diseases. The qualitative risk assessment of FMD in Sierra Leone was planned under the ECTAD program, FAO Sierra Leone.

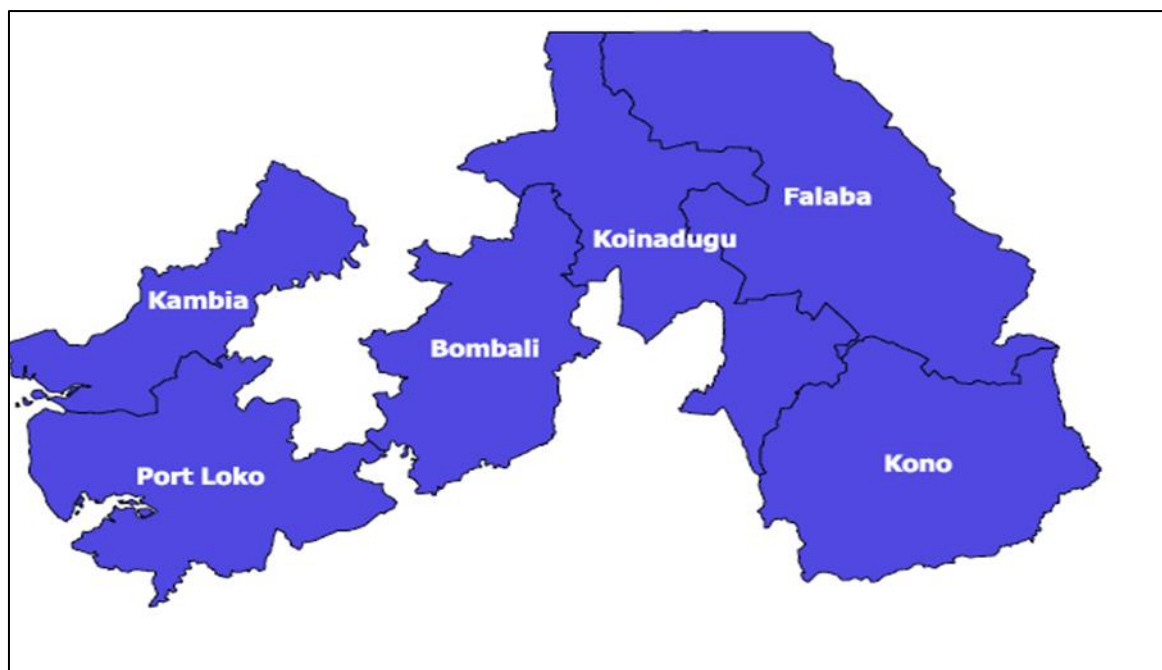


Figure 1: Target districts of the study

1.1 Objective of study

The overarching objective of the study is to assess and map the risk of the introduction and spread of FMD in the country in order to optimize FMD surveillance system and FMD control measures.

2 AN OVERVIEW OF FOOT AND MOUTH DISEASE(FMD)

Foot and Mouth Disease (FMD) is a viral disease that has negative impact on farmers and stakeholders along the livestock value chain in endemic countries, and when introduced into FMD previously free countries(Cooper, 1993). The impacts encompass direct losses that limit livestock production (such as decreased milk production, lower weight gains, decreased fertility and increased mortality mainly in young animals), as well as costs associated with the response to disease or infection (such as treatments, vaccination, movement controls sample collection and stamping out,). FMD endemic countries are denied access to potentially lucrative export markets for livestock and livestock products, giving governments a clear incentive to chain resources to control the disease(Cooper, 1993). It is often assumed that by controlling the disease and acquiring the World Organization for Animal Health (WOAH) 'free without vaccination' status, all animal holders (regardless of the production system, size, and access to markets) would benefit, either by increasing their income or increasing availability of Animal-Source Food (ASF), such as milk and meat, in the household (Jenkins, 2013). However, the benefits of controlling the disease in low- and middle-income countries (LMIC) are complex and not well quantified (Jenkins, 2013). Furthermore, impact of FMD and consequences of the control programmes on livestock holders' livelihoods and food security is rarely explored. Studies have focused on quantifying the impact of the disease in mixed farming systems in Africa and Asia, and large-scale commercial or pastoral systems in Africa (Rose et al, 2011).

Foot and Mouth Disease can severely affect and disrupt national, regional and international trade in livestock and livestock products(Beckerson, 2012). The burden of FMD in developing countries like Sierra Leone, involves the loss of animals and a lowering of production efficiency. FMD is endemic in Sierra Leone and threatens food security and the livelihoods of smallholders and prevents animal husbandry sectors from developing their economic potential(FAO, 2013).

Since FMD outbreak was reported in 1958 (VSD) and reoccurred in 2018, no vaccination has taken place(FAO, 2010) The outbreak investigation undertaken for reported FMD outbreak by MAF, FAO-ETAD and Njala University in Tonkolili, Kono, Kambia and Koinadugu Districts in August and September 2018, shows that there was cattle mortality of 15.5% in Kambia district 2.4% in Koinadugu district and 19.6% in Bombali district(Ministry of Agriculture, 2013). Thus, there was reduced production and productivity and loss of income to farmers, food security and nutrition. If a comprehensive risk assessment campaign is conducted, the tendency for the disease to spread will be curtailed or minimized

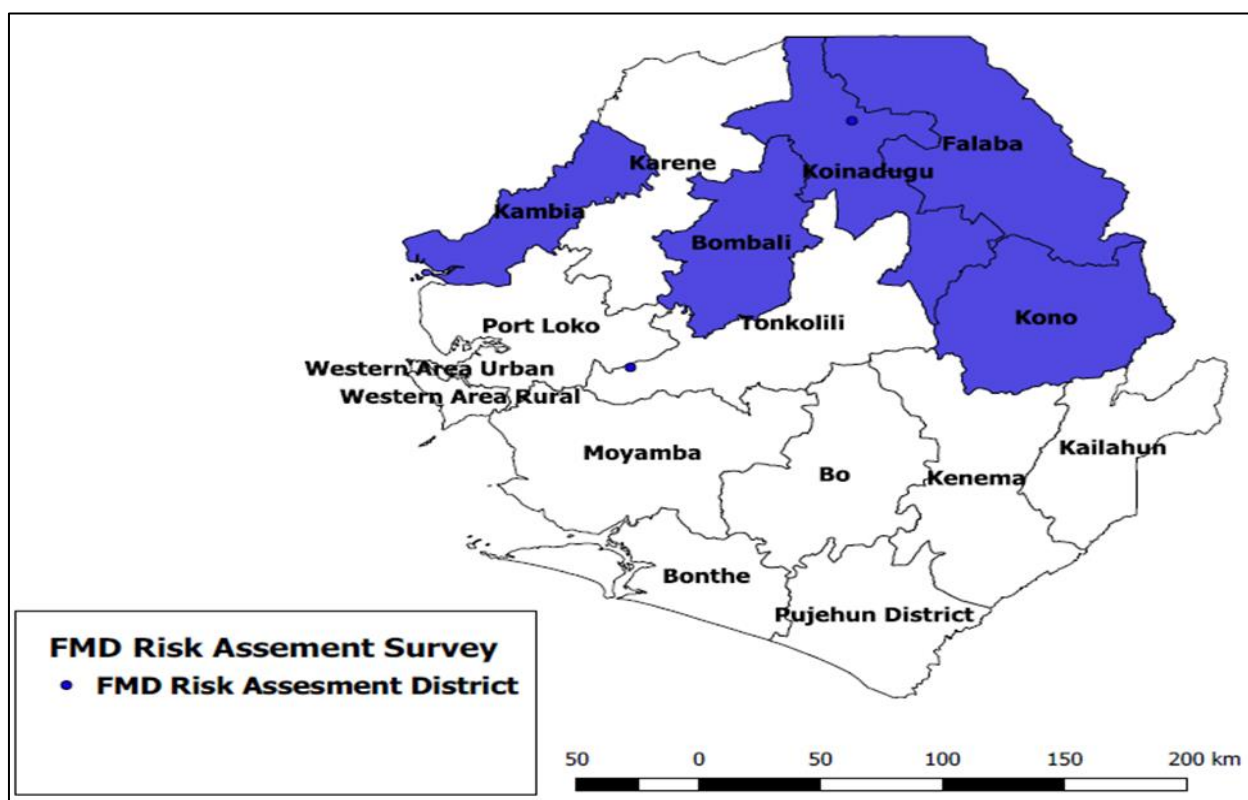


Figure 2: Map of Sierra Leone showing Study Districts.

3 MATERIALS AND METHODS

The study was conducted through a purposive sampling strategy in 6 districts in the North and North-East Sierra Leone. A total of 240 participants in 24 chiefdoms, and 48 communities was recorded. Because of its qualitative attributes, the assessment employed descriptive design to prompt information on the existing phenomena. A total of 4 chiefdoms were randomly selected in each district, and 2 communities selected in each chiefdom, with 5 household interviews conducted in each of the selected communities. The respondents comprised of Livestock farmers, Livestock traders and other pastoralists.

The data collection tools were pre-tested to ensure quality assurance before actual field work, which lasted for 6 days (From the 18-23 October, 2023).

As mentioned above, the questionnaire was constructed to identify risk factors including animal mobility for assessment and mapping of the risk of introduction, spread and occurrence of FMD in Sierra Leone.

The following assessment indicators were taken into account.

- Assessing the likelihood of risk of introduction of FMD from the 2 neighboring countries of Guinea and Liberia, and the potential of spreading in communities of Sierra Leone bordering the 2 countries. It was noted that at the time of the study, none of these 2 countries have reported an FMD outbreak. At this level, the legal and illegal movement of Livestock and products and the control system at the border was the main risk factors considered to assess the risk of introduction of the disease from the neighboring country into Sierra Leone.
- The 2nd step was to assess the likelihood of the disease spreading once it is introduced. To this end, the density of cattle goats, sheep and other small ruminants was taken into account as well as the accessibility (density of road) and the animal mobility.

3.1 Data collection

A triangulation of method and data was used to collect data on the main risk factors. The risk factors were identified taking into account the availability of the data and the ability to source respondents. The accessibility of secondary data provided by FAO and the Ministry of Agriculture and Forestry in Sierra Leone, aided the researcher to collect data with empirical precision taking into cognizance the objective of the study.

With the assistance of District Livestock Officers (DLOs) in each of the districts, data collection was done in an atmosphere of cordiality and frankness. The DLOs coordinated and informed the targeted respondents about the survey. upon which the researcher was able to execute the study. The collected data was analyzed through QGIS to create risk maps, especially those that have to do with the study area and the movement of livestock within the area under review

3.2 Limitations/Challenges faced during data collection.

Some of the challenges that were faced by research team during the interviews were:

- Some of the participants recruited refused to participate in the interviews for the scheduled days and time. The researcher had to either find other participants who suited the criteria or postponed the interview to dates appropriate to the interviewees. Those that refused to participate were replaced.
- The Mountainous and rough terrains of the study areas posed some constraints that somehow slowed data collection in some communities, that resulted in missing out some respondent who had gone to their farms by the time the researchers got to the communities.

3.3 Data analysis and interpretation

In the absence of epidemiological or laboratory data on diseases, respondents were asked to mention disease clinical signs which were recorded, and based on a checklist, a specific disease was indicated by the data collectors or during data entry. The QGIS software was used for data analysis and mapping. Four risk categories (negligible, low, high and very high) were used to qualify the risk of the introduction and spread of FMD in Sierra Leone as illustrated on the table below;

It is prudent to state that, the absence of vital data and one that has not been updated may incurred an uncertainty in the estimation of the levels of probability. Data collection on the likelihood of risk is achieved by combining risk factors.

Table 1: Risk category and interpretation

Risk Category	Interpretation
Negligible	Event is so rare that it does not merit to be considered
Low	Event is rare but does occur
High	Event occurs very often
Very high	Event occurs almost certainly

The probability of introduction was calculated on a total score of twelve (12) distributed by expert opinion according to their importance and constructed from data related to the epidemiological status of neighboring countries, the existence of commercial movements (legal or illegal), and the evaluation of the reality of the actions carried out in the field in terms of surveillance, and control of the targeted disease. Each column was assigned a weighting coefficient on the spread of animal diseases between countries, in relation to the importance and consequences of the situations and activities carried out (Dufour et al – *A qualitative risk assessment methodology for scientific expert panels. Scientific and Technical review of the OIE*, 30(3):673-81.). The levels of introduction probability were defined as presented in Table 2 below.

Table 2 Categorization of the probability of introduction and conversion into qualitative risk

- 1, 2 and 3: Negligible
- 4, 5 and 6: Low
- 7, 8 and 9: High
- 10, 11 and 12: Very high

(AFSSA, 2008.
https://www.academia.edu/68128035/Une_m%C3%A9thode_qualitative_destimation_du_risque_en_sant%C3%A9_animale)

The Social Network Analysis (SNA) was performed with R software. Initially, a descriptive analysis of the data was carried out, with the aim of characterizing the interested sub-prefectures and studying their variations over time in terms of movements and volume of animals moved. Measures of centrality were used to quantify the importance of nodes and links within the network. The flow of incoming animals called "InDegree" was considered in the analysis of introduction probability.

The categorization of the risk of introduction taking into account the probability of introduction and the flow of animals was as follows:

- **Very high risk:** ("Prob_Intro" = 4) and ("InDegree" >2)
- **High risk:** ("Prob_Intro" = 3) and ("InDegree" >1)
- **Low risk:** ("Prob_Intro" = 2) and ("InDegree" >0)
- **Negligible risk:** ("Prob_Intro" = 1) and ("InDegree" <0)

Thus, the risk of introduction is considered very high for county when the probability of introduction is equal to 4 and the inflow of animals greater than 2; the risk of introduction is considered high for cattle when the probability of introduction is equal to 3 and the inflow of animals greater than 1 ; the risk of introduction is considered low for cattle when the probability of introduction is equal to 2 and the incoming flow of animals is greater than 0; the risk of introduction is considered negligible for cattle when the probability of introduction is equal to 1 and the incoming flow of animals is less than 0.

The risk of spread of cattle to FMD, i.e., after the disease has been introduced, was categorized by considering the risk factors cattle density ("Dens_Bov"), accessibility ("Access"), and SNA mobility ("Degree" and "Betweenness") as follows

- **Very high risk:** ("Dens_road" >8.9)+ ("Dens_CT" >555) + ("Degree">6) + ("Betweenness" >0.59)
- **High risk:** ("Dens_road" >5)+ ("Dens_CT" >290) + ("Degree">3) + ("Betweenness" >0)
- **Low risk:** ("Dens_road" >2.7)+ ("Dens_CT" >170) + ("Degree">1)
- **Negligible risk:** ("Dens_road" <2.7)+ ("Dens_CT" <170) + ("Degree"<1)

4 RESULTS

Table 2 The score and the probability of risk of introduction of FMD in the two bordering countries considering the epidemiological status, legal and illegal movements, surveillance system, prevention and control measures as the major risk factors.

RISK OF FMD INTRODUCTION FROM BORDER COUNTRIES INTO SIERRA LEONE														
Border Countries	STATUS	Legal trade with high-risk countries (1)	Illegal movements (3)	Surveillance system (2)				Prevention and control (3)					TOTAL (12)	Probability of the risk of introduction estimated
	Status in the past (3)													
				R.O. (0,25)	Surv. Active (0,5)	Surv. Passive (0,5)	Risk based surveillance (0,75)	Cross-border control (1)	Stamping out (0,5)	Sanitary slaughter around the outbreaks (0,5)	Zoning and restriction of mvts (0,75)	Ring vaccination (0,25)		
Guinea	1.5	0	2	0	0.25	0	0	0.5	0	0.5	0.75	0.25	5.75	LOW
Liberia	1.5	0	1	0	0	0	0	0.5	0	0	0	0.25	3.25	NEGLIGIBLE
Source: Field Data, 2021														
CATEGORIZATION OF PROPABILITY AND CONVERSION INTO QUALITATIVE RISK														
SCORES		PROBABILITY												
1,2 and 3		Negligible												
4,5 and 6		Low												
7, 8 and 9		High												
10, 11 and 12		Very High												

The risk of spread was considered very high for regions when the centrality measure ("Degree") of the SNA was greater than 6, the accessibility greater than 8.9 and the cattle density greater than 555 and the Betweenness greater than 0.59. The risk of exposure was considered high when the degree was greater than 3, accessibility greater than 5, cattle density greater than 290 and the Betweenness greater than 0. The risk of exposure was low when the centrality measure ("Degree") was greater than 1, accessibility greater than 2.7, and cattle density greater than 170. The risk of exposure was negligible when the centrality measure ("Degree") of SNA was less than 1, accessibility less than 2.7, and cattle density less than 170.

4.1 Risk of FMD introduction into Sierra Leone

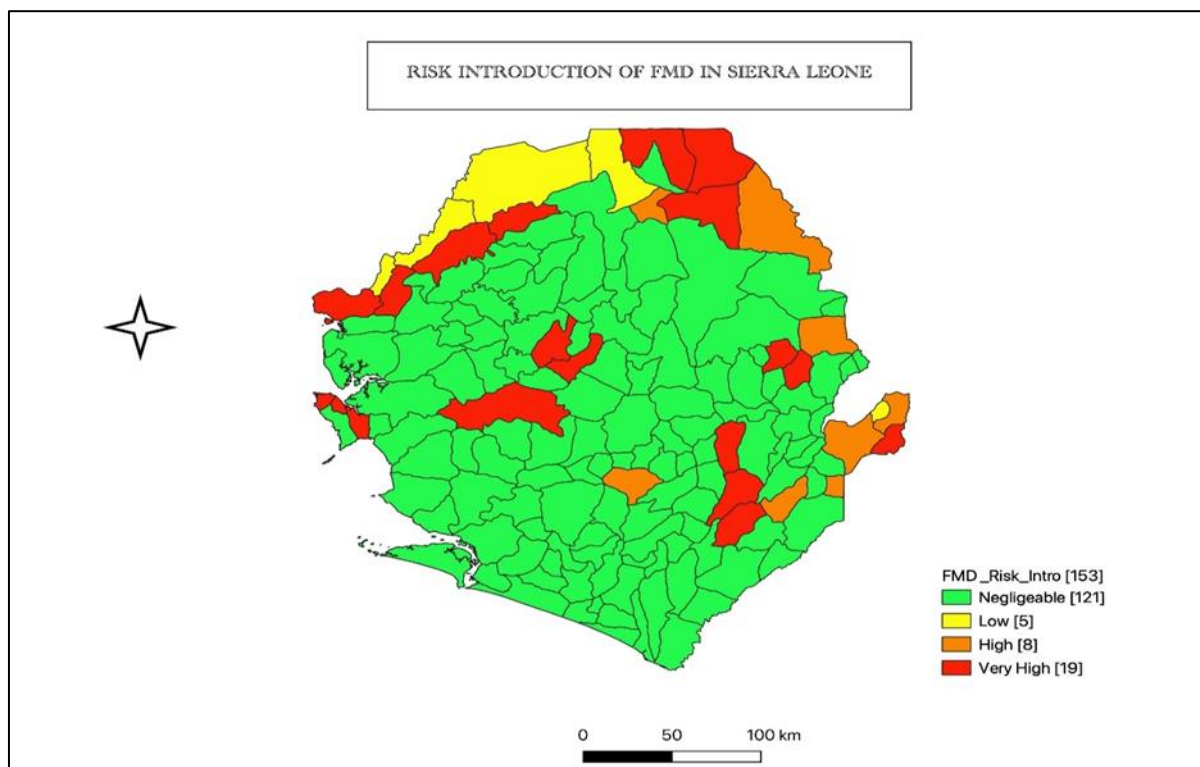


Figure 3: Map showing FMD introduction risk into Sierra Leone.

The map above illustrates the risk of FMD introduction into Sierra Leone. From the data collected, it is prudent to state that the risk of FMD introduced from the neighboring countries especially from Guinea is low. This rationale behind this finding was couched from the fact that, animal mobility from this area during the data collection period was irregular as a result of other restrictions and for economic reasons. Farmers lamented that, majority of the traders from Guinea stopped doing business in Sierra Leone because of the unattractive nature of the business as a result of the rapid devaluation of the Sierra Leone currency as against the Franc. These circumstances resulted to less animal mobility, and as such low incidences of FMD.

Even though most of the information provided by the farmers and traders was retrospective of the outbreak of FMD in 2017-18, there was less information as regards the high prevalence of FMD in the areas visited. Even though the study establishes that the risk of introducing FMD into Sierra Leone through Guinea is low, however, the map shows that the northern part of the country is prone to future outbreaks if robust surveillance is not instituted.

The map shows the risk of introduction of FMD from Liberia as Negligible. This is due to the fact that majority of ruminants both large and small are imported through Guinea, a very close neighbor to Sierra Leone as compared to Liberia. The threat of FMD being introduced from Liberia is insignificant at the moment but could occur from Guinea.

4.2 Risk of FMD Spread once introduced into Sierra Leone

In a bid to gather information about the potential risk of FMD spread once it is introduced into Sierra Leone; the researcher posed questions to the research participants to get their perspectives. Data captured on the risk of spread was displayed on the map below.

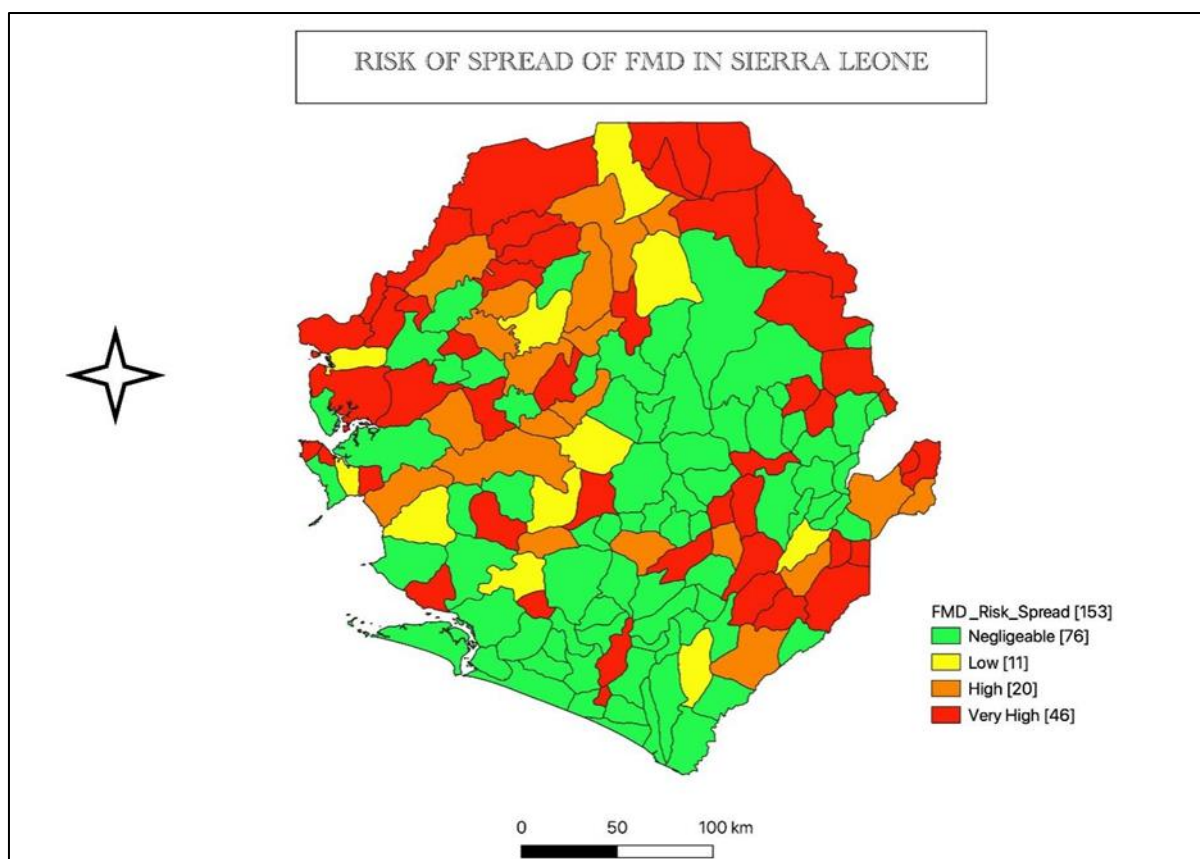


Figure 4: Map Showing risk of FMD spread into Sierra Leone.

It is evident from the above map that the risk of spread of FMD once introduced into Sierra Leone could be high and very high, especially in communities in the northern part of the country as compared to those in the East, as far as the study sites were concerned. The risk of FMD spreading into Sierra Leone from the border towns of the north could be attributed to the high animal mobility within the communities, especially at those close to the border towns. Since these animals are not sedentary, there is a possibility of intra and inter- community infection as they move around apparently to graze.

Table 3: Number of districts by probability of FMD risk of Introduction

District	Probability of FMD risk of Introduction				Total
	Negligible	Low	High	Very high	
Kono	15	32	0	0	47
Koinadugu	23	22	0	0	45
Falaba	15	22	3	1	41
Kambia	8	28	0	4	40
Bombali	3	33	0	0	36
Port Loko	15	16	0	0	31
Total	79	153	3	5	240

Source: Field Data, 2023.

As illustrative on table 5, 33(13.8 %) of probability risk of FMD in Bombali district is low and a negligible risk of 1.3% whilst Kono, Koinadugu, Falaba and Kambia have low probability risks of 32(13.3%) 22(9.2%) ,22(9.2%) 28(11.5%) respectively. With negligible risks of 15(6.3%), 23(9.6%) 15(6.3%), 8(3.3%), 3(1.3%).

FMD risk of introduction in these districts has demonstrated low outcomes especially in Bombali district at the time of the conduct of the study but this could be attributed to the low trend of FMD in these places. The districts of Kono,

Koinadugu, Falaba and Kambia have communities closer to the border with Guinea but a considerable low threat of the disease is recorded at the moment because of the restricted movement of livestock into these areas coupled with the currency fluctuations of these countries (Sierra Leone and Guinea). Livestock traders opined that the devaluation of the Leone as against the Franc has contributed to a major reason for traders bringing livestock into Sierra Leone.

Table 4: Number of districts by probability of FMD risk of spread

District	Probability of FMD risk of Introduction				Total
	Negligible	Low	High	Very high	
Kono	2	3	1	4	10
Koinadugu	4	8	10	15	37
Falaba	5	6	12	20	43
Kambia	3	6	30	44	83
Bombali	7	8	12	10	37
Port Loko	8	2	10	10	30
Total	29	33	75	103	240

Source: Field Data, 2023

As illustrative on table 6, 44(18.3 %) of probabilities risk of FMD spread in Kambia and Falaba 20 (8.3%) are high as compared to other districts. This explained the fact that these districts have the most frequent animal movements from Guinea. An interesting finding is that districts in the north especially those close to the border areas have high risk of FMD spread.

5 DISCUSSION

It is empirical to affirm that, the introduction of FMD in Sierra Leone is contingent on the risk of introduction from Guinea, which is currently low in terms of risk. The risk of spread of FMD is high in the districts of Kambia and Falaba. The risk from Liberia is practically negligible as much of the livestock is coming from Guinea. Sierra Leone first experienced FMD outbreak in 1958 and later reoccurred in 2018-2019. Much in terms of risk has not been recorded including the current study. This should be a cautious optimism that the disease could raise its ugly head into Sierra Leone if veterinary services are not prioritized. Although the risk FMD introduction from Liberia is negligible, active surveillance should be the norm rather than the exception, because there is a likelihood of traders to be attracted to move livestock from the Liberia end as a result of the improved road infrastructure in Sierra Leone and the increased demand of ruminants in the cities of Bo in the South and Kenema in the east.

The districts under review are considered as low risk areas of FMD introduction, especially those bordering with Guinea. However, as illustrated on the maps the risk in some communities such as those organizing livestock market centres could be high as a result animal density during the periodic market days, and particularly in the dry season when pasture and water are scarce.

The Lack of sufficient data on animal density in the districts, some data points in terms of risks were not considered. However, several surveys on risk assessment have created empirical evidence that established the evidence of ill-composed livestock markets in some areas as compared to other areas. This is true for Port Loko district and organized livestock markets in Gbindi, Folamasa, in Falaba district and Kumbayendeh in Kono district respectively.

6 CONCLUSION

The study was conducted to assess and identify the risk of FMD introduction, spread and re-occurrence in Sierra Leone. It is hoped that findings of this assessment will better serve as practical guide to help build a robust veterinary surveillance system in areas of potential risks. On account of the risk factors and data generated in this study, the probability of FMD re-occurrence into Sierra Leone is low, but the risk of spread is high in some districts. Nevertheless, the unavailability of reliable and updated data on certain risk factors such as ring vaccinations and market statistics, the results should be viewed with some uncertainty and be considered changing from time to time. It is believed that an update of this data will minimize the dynamics of future qualitative risks assessments. The empirical precision of the data and results of this study are in tandem with the data available during the assessment.

Recommendations

From the results generated, it is imperative that the following recommendations are taken into account on the risk preventive measures.

Risk based surveillance (To the Veterinary officers)

- Sustain the active surveillance of FMD and update the active surveillance plan, targeting as a priority the districts including hotspots of FMD spread such as livestock markets to maintain the status of Low risk.
- Strengthen the surveillance process by training and allocating more resources to all available quarantine officers at active point of entry and paddocks to tackle the spread and risk of introduction.
- Deploy trained personnel to undertake surveillance activities in the potential risk areas revealed by the assessment.
- Update and operationalize the FMD emergency and surveillance plans.
- Prioritize veterinary work over bribes and kickbacks for vaccines and other animal drugs.
- Collaborate with community stakeholders to identify risk areas to execute control measures.
- Cooperate with the government through the veterinary division of the Ministry of Agriculture and Forestry to identify of risk areas and on matters related to animal health and disease control.
- Report any health events related to animal disease.

Cross border Control- To the Veterinary officers)

- Intensify border patrol for illegal movements of livestock into the country.
- Ensure all livestock are quarantined before transported to paddocks
- Build farmers capacity to mitigate FMD risk of introduction and spread along the value chain actors (implementation of good practices, Biosecurity,...

Stamping Out- (To the veterinary officers)

- Slaughter animals suspected with FMD to prevent spread and occurrence of the disease.
- Dispose of dead bodies of animals infected with FMD to prevent spread of the disease and consumption by farmers.
- Compensate farmers whose animals were stamped out as a result of FMD.

Sanitary slaughter around the outbreaks- (To the farmers)

- Cooperate with the veterinary officers to identify FMD outbreaks around slaughter houses and abattoirs
- Isolate from the slaughter houses animals suspected of FMD

Zooning and restriction of movement –(To the veterinary officers)

- Restrict illegal movement of livestock, especially those that show clinical signs of FMD.
- Monitor and seal all illegal border entry points of livestock.

Ring Vaccination

- If practicable inoculate all livestock from border countries deem to have cases of FMD.
- Conduct comprehensive vaccination campaigns for all livestock to prevent infection and community transmission.

To FAO and other technical and funders

- Continued efforts to support the veterinary service system in operationalizing FMD risk control measures in the assessed districts and other areas in the country

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS
Acknowledgments

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Disclosure of conflict of interest

The development of the manuscript was done in an atmosphere of cordiality and frankness as reflected in the outcome of the study. The authors declare no conflicts of interest regarding this manuscript.

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APPENDICES



Small ruminant farmer displaying affected goat with skin diseases at Lei community , Kono district



Open Goat shed at Gbindi, Falaba district