Socio-economic and epidemiological study on foot and mouth disease control in Sri Lanka

2022

ATHAMBAWA Mohamed Jiffry

Doctoral Program of Animal Science and Agriculture

Graduate School of
Animal and Veterinary Sciences and Agriculture

Obihiro University of Agriculture and Veterinary Medicine

スリランカにおける口蹄疫コントロールの
社会経済疫学的研究

令和 4 年

(2022)

帯広畜産大学大学院畜産学研究科
畜産科学専攻博士後期課程

アタンバワ　モハメド　ジェフリー

Table of contents

CHAPTER 3 Farmers' knowledge, attitudes and practices regarding foot and mouth disease

CHAPTER 4 Factors affecting vaccination behavior for foot and mouth disease

CHAPTER 5 Farmers' embedded indigenous behavior and adoption factors for the control of foot and mouth disease

List of abbreviations

AI	Avian Influenza
AR	Annual Report
ASF	African Swine Fever
BQ	Black Quarter
BSE	Bovine Spongiform Encephalopathy
BTB	Bovine Tuberculosis
CBPP	Contagious Bovine Pleuropneumonia
CMT	California Mastitis Test
CSF	Classical Swine Fever
DAPH	Department of Animal Production and Health
DCS	Department of Census and Statistics
DG	Director General
DS	Divisional Secretariat
EB	Epidemiological Bulletin
EP	Eastern Province
EuFMD	European Commission for the control of Foot and Mouth Disease
FAO	Food and Agriculture Organization
FAST	Foot-and-mouth And Similar Transboundary animal diseases
FMD	Foot and Mouth Disease
FMDV	Foot and Mouth Disease Virus
FMS	Famer Managed Societies
GDP	Gross Domestic Production
GND	Gramma Niladhari Divisions
HBM	Health Belief Model
HS	Haemorragic Septicaemia
ILRI	International Livestock Research Institute
KAP	Knowledge, Attitudes and Practices
LRA	Linear Regression Analysis
LSB	Livestock Statistical Bulletin
MILCO	Milk Industries of Lanka Company Limited

MMDE	Ministry of Mahaweli Development and Environment
ME-SA	Middle East-South Asia
ND	Newcastle Disease
NLDB	National Livestock Development Board
OIE	World Animal Health Organization
PCP	Progressive Control Pathway
PDAPH	Provincial Department of Animal Production and Health
PPR	Peste des Petits Ruminants
RP	Rinderpest
RVF	Rift Valley Fever
S-19	Strain 19
SAARC	South Asian Association for Regional Cooperation
SAT	South African Territory
SLR	Sri Lankan Rupee
TAD	Transboundary Animal Diseases
TM	Text Mining
TPB	Theory of Planning Behavior
UK	United Kingdom
US$	United States Dollar
USAID	United States Agency for International Development
VIC	Veterinary Investigation Center
VRI	Veterinary Research Institute
WHO	World Health Organization
WRLFMD	World Reference Laboratory for FMD
Km	kilometer
mm	millimeter

List of tables

List of figures

Socio-economic and epidemiological study on foot and mouth disease control in Sri Lanka

CHAPTER 1

Introduction

1.1 Background and challenges

Livestock production in the developing world occurs in a wide range of heterogenous production system, ranging from pastoral to grassland-based systems. These contributions trend increase, as most future growth in livestock production is projected to occur in developing world (Bruinsma, 2003). Most meat and milk in the developing world come from mixed system (Seré et al., 1996; Steinfeld et al., 2006; Herrero et al., 2009). Livestock production in developing countries are important economic activity. Livestock products are high value products, especially when compare with crops (FAOSTAT, 2011). The growth in demand for milk and meat, mainly driven by urban consumers in developing countries, has been increasing in the last few decades and is projected double by 2050 (Delgado et al., 1999; Rosegrant et al., 2009). The growing demand for animal source food in developing countries, caused by a combination of population growth, rising per capita incomes and progressive urbanization, linked to livestock revolution (Delgado et al., 1999). An estimate of half a billion of the world's population extreme poor, who depend on livestock for part of their livelihood, may potential benefit from the expanding market for food of animal origin (Brown, 2003; Catley, 2008; Delgado, 2003; ILRI, 2008) and growth of livestock sector affected by negative externalities by environment and public health (Barrett, 2001).

The world food economy is increasingly driven by the shift in diet and food consumption patterns towards livestock products. The consumption growth of animal source food in the world indeed impressive data between 1980 and 2003, the consumption of meat in developing countries increased from 47 to 143 million tons, milk from 112 to 239 million tons and eggs from 8 to 37 million tons in per capita consumption. Per capita consumption is rapidly increasing in regions where urbanization and increase income growth result in people adding different diets. Across countries, per capita consumption is significantly decided by average per capita income (Cranfield et al., 1998). Especially, in the last few decades, in the developing countries of Asia where the bulk of the world population is increasing. Consumption of meat has been growing at over 4% per annum and milk and dairy products between 2% to 3% per annum (FAOSTAT, 2010). An estimated 70% of the world's rural poor whose livelihood depend on the livestock, have not benefited from this growth in the livestock sector (Otte and Upton, 2005), even though they produced about 50% of the beef, 41% of milk, 72% of lamb, 59% of pork and 53% of poultry globally (Herrero et al., 2009).

The livestock diseases are threat to low production in animal husbandry. There are many reasons for decreasing the growth of livestock sector. These factors range from poor nutritional practices, poor marketing systems, inadequate extension services and insufficient resources. Losses due to livestock diseases are one cause of low milk production and incomes. The livestock impacts on poverty reduction and attempts to prioritize the livestock diseases relevant to the poor (Perry and Grace, 2009).

In poor countries livestock is the main livelihood income generating source. Since, around one fourth of livestock is lost due to animal diseases in the world. The livestock loss threatens poor family's food security. These losses cause deprivation to one third of urban poor who only depend on livestock (Kilian, 2012). Transboundary animal diseases (TAD) are of economic significance, trade and food security importance for a considerable number of countries; which can easily spread to other countries, and potentially interfere trade relation. The important TADs are including foot and mouth disease (FMD), Rinderpest (RP), contagious bovine pleuropneumonia (CBPP), Bovine spongiform encephalopathy (BSE), Rift valley fever (RVF), Peste des petits ruminants (PPR), classical swine fever (CSF), African swine fever (ASF), Newcastle disease (ND) and Avian influenza (AI) (Otte et al., 2004).

Transboundary livestock diseases such as FMD have a direct economic impact by reducing agricultural and animal production (FAO/ OIE, 2004; Domenech et al., 2006). To prevent the TADs, countries must have in place a suitable contingency plan to respond quickly to high threat diseases (Basagoudanavar and Hosamani, 2013). FMD is one of most contagious transboundary animal diseases. FMD is a highly contagious viral infection with significant transboundary movement among cloven-footed animals and cause economic losses (Brito et al., 2017; Bronsvoort et at., 2004). FMD is caused by foot and mouth disease virus (FMDV) belonging to genus *Apthovirus* of the family *picornaviridae* (Grubman and Baxt, 2004; Samuel and Knowles, 2001). It consists in diagnostically seven different serotypes namely, O, A, Asia 1, South African Territory 1 (SAT 1), SAT 2, SAT 3 and C however, serotypes O, A and Asia 1 are mostly prevalent in India (OIE, 2004, Subramaniam et al., 2013a). FMD causes greatest production losses in cattle and pigs and in particular in intensive dairy and pig production system. Livestock movements and trade plays a key role in the spread of disease. FMD is still endemic throughout the world. It is occurring in large part of Africa, the Middle East, Asia and the countries that are free of FMD remains under constant threat of an outbreak. In FMD endemic countries, usually developing countries, threatens food security and livelihood of smallholder farmers. The direct economic impact of the disease cause reduces in milk production, abortions and deaths (mainly young animals) and indirect effects include the loss of draught power for crop production, transportation, and cost for implementing FMD control measures (Rweyemamu et al., 2008). FMD cause social impact in southeastern Asia in rural and national level (Khounsy et al., 2008).

FMD has been present in Sri Lanka since middle of the nineteenth century (Wijewardana and Fernando, 1983). FMD epidemic commonly occur in every four to six years in Sri Lanka (Fernando, 1969a). Livestock sector is an integral part of the agriculture which contribute 25.9% of the labor force. In agriculture sector, 64.2% is contributed by family workers mainly involve as small holder traditional practices (DCS, 2020). In 1984 FMD outbreak occurred in northern, western and Uva provinces in Sri Lanka, again the outbreak in 1987 resulted 86,000 cases (Kodituwakku, 2000). There is a continuous FMD outbreak occur each year. Animal movement have been recognized as the main route of transmission of disease in endemic regions (Donaldson, 1987; Paton, et al., 2018). Most common mechanism of transmission of FMD in Sri Lanka is by movement of clinical and sub clinical animals. The number of 11,326 FMD cases and 83 deaths reported in 107 veterinary ranges in eighteen districts in year 2019. FMD epidemics always commenced during north-east monsoon with rainy season between December and February. This coincides with the seasonal movement of livestock management practices specially in dry zone (DAPH, 2019). The accepted control measures for FMD are stamping out, tracing the outbreaks, regulations, quarantine, movement control, vaccination and hygiene practice. Culling of infected animals and compensation for farmers were not practiced due to financial limitation like in developed countries. Even if animal health regulation prevents infected animals, illegal transportation is possible due to various socio-cultural pattern. Identification of FMD control challenges and economic impact may provide opportunities for considering the acceptable control pathway. The significant challenges of controlling FMD due to animal movement, inadequate knowledge among farmers, farmers' cooperation to vaccination and traditional practices to prevent FMD outbreak. Enforcing animal movement restriction is often a challenge and disease easily spread to new areas rapidly before it can be kept under control. FMD persistence continue a result of inadequate epidemiological understanding of the disease and ineffectiveness of the control measures that are being applied. Therefore, the general objective of the dissertation is to clarify the present foot and mouth disease status and related farmers' behavior, provide inputs for integrated effective control strategy in Sri Lanka to formulate the policy recommendation.

1.2 Literature review

For general objective that, the related literature review was described on the following topic on epidemiology and risk factors, socio-economic of FMD, farmers' knowledge, attitudes and practices (KAP), disease control measures and eradication policies, farmers' embedded behavior and adoption of sustainable control and asymmetry information and externalities in FMD control strategies.

1.2.1 FMD epidemiology and risk factors

Globally, the FMD is a highly contagious disease that can cause severe economic losses to cattle and buffalo farmers (Perry and Randolph, 2003) and also cause diseases of other cloven hoof animal like pig, sheep and goats, and is one of the most important economic diseases of livestock (Broonsvoort et al., 2004; OIE, 2019). The disease is characterized by fever and vesicular eruption in the mouth, nares, muzzle, foot, and other hairless soft areas of the body (Grubman and Baxt., 2004). FMD does not cause high mortality in adult animals, but has weakening effects, including weight loss, decrease in milk production, reproductive failures and loss of draught power resulting in low productivity. Mortality is high among young animals, wherein the virus causes myocardial degeneration, known as tiger heart disease (Gleeson et al., 2002). The clinical disease varies with species, breed of animal affected, and serotype and strain of foot and mouth disease virus (FMDV) (Kitching, 2002). Table 1.1shows FMD serotypes have been described, namely, A, O, C, SAT1, SAT2, SAT3 and Asia 1 (Grubman and Baxt, 2004). Serotypes C was last detected in Kenya and Brazil in 2004 (Sangula et al., 2011). African buffalo is known to be the main wild life reservoir for SAT serotypes in Africa (Vosloo et al., 2007; Thomson et al., 2009).

FMD control programs should be designed based on current knowledge of FMD status at a global level. The distribution of different viruses is relevant to determine targeted surveillance, to tailor control strategies and to decide vaccine antigens that should be used in each area. Endemic areas have been described in seven geographical FMDV pools (Figure 1.1) that share similar viruses (Rweyemamu et al., 2008; Paton et al., 2009). These virus pools are often the result of ecological similarities, common livestock exchange and cultural tradition.

Table 1.1 FMD pool and serotypes

Pool	Region	FMD serotypes
1	Southeast Asia/ Central Asia/ East Asia	A, Asia 1, and O
2	South Asia	A, Asia 1and O
3	West Eurasia and Middle East	A, Asia 1, and O, SAT 2
4	North Africa	A, O and SAT 2
5	West and Central Africa	O, A, SAT 1 and SAT 2
6	Southern Africa	SAT 1 SAT 2 and SAT 3, O, A
7	Southern America	O and A

Source: EuFMD, 2020

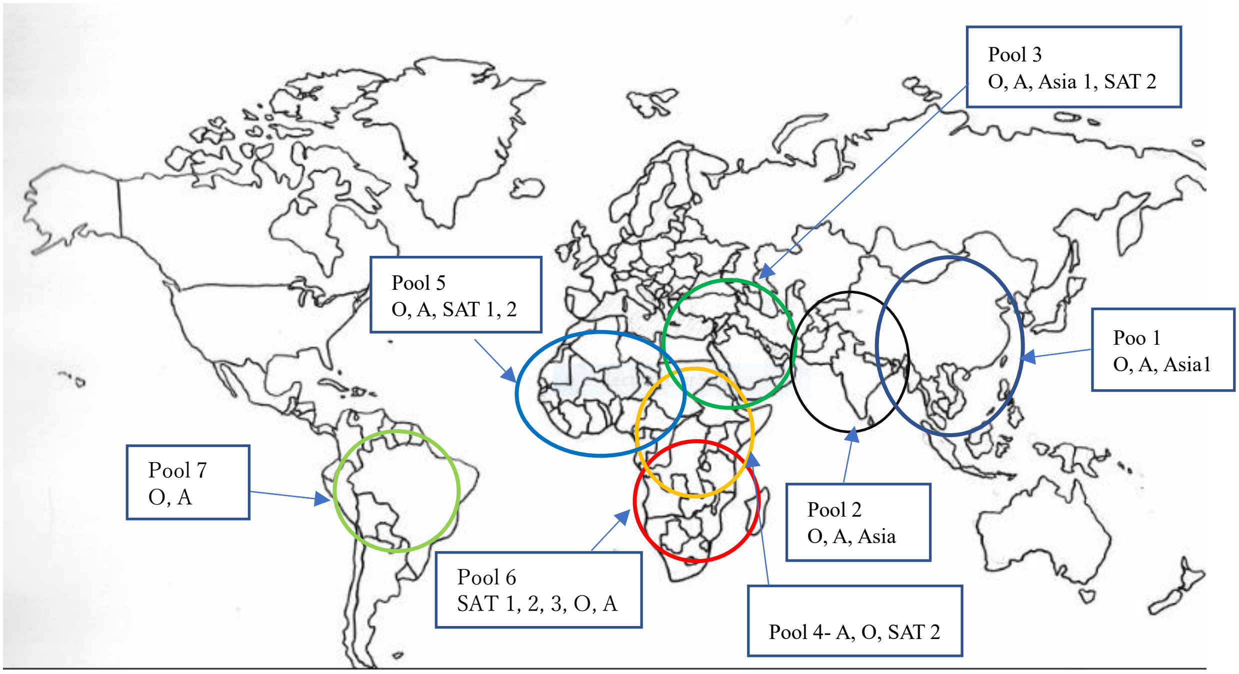


Figure 1.1 Distribution of FMD countries in the seven FMD virus pool

Source: WRLFMD, 2020

To date, only FMDV serotype O and C have caused outbreaks in Sri Lanka. The FMDV samples from the first outbreak in 1950 were serotyped and identified as serotype O by a Danish laboratory. The systematic surveys conducted from 1962 to 1967 and 1977 to 1981 revealed the presence of serotype O in Sri Lanka (Fernando, 1969b; Wijewardana and Fernando, 1983). The FMDV infections were reported during 1997 to 2019 (Figure 1.2), where the numbers were higher in 1997, 1999, 2003 and 2014 (Gunarathne et al., 2016; DAPH, 2019). The FMD viral lineage Srl-97 caused three endemic situations in 1997, 1999, and 2000 (Abeyratne et al., 2018). The huge outbreak was recorded through all provinces resulting 69,296 infected cattle and buffalo and lead to 1,995 deaths in 2014 and this outbreak was suspected to be introduced from India by illegal movement of animals (DAPH, 2014). FMDV strains collected during 2014 outbreak belong to the lineage, Ind-2001d, of the topotype. ME-SA (Abeyratne et al., 2018). The strains collected in 2012 and 1997 belonged to another lineage called 'unnamed' by the World Reference Laboratory for FMD (WRLFMD). This unnamed lineage designated as 'Srl-97' which is endemic to Sri Lanka (Abeyratne et al., 2018). According to the analyze of FMDV capsid protein and complete genome sequences, the outbreaks of Ind-2001d in Sri Lanka which occurred in 2013 and 2014 were different from each other (Ranaweera et al., 2019). FMDV lineages of the 2013 and 2014 epidemics were closely related to the contemporary Indian FMDV (Bachanek-Bankowska et al., 2018). FMDV serotype C was first identified in Sri Lanka in 1954 by serotyping of two samples at the Veterinary Research Institute, Pirbright, England: even though, these viral isolates are no longer cause disease. Serotype C was thought to be accidentally introduced from India in 1970, which cause massive outbreak in Sri Lanka till 1975 (Gunasekera and Fernando, 1980).

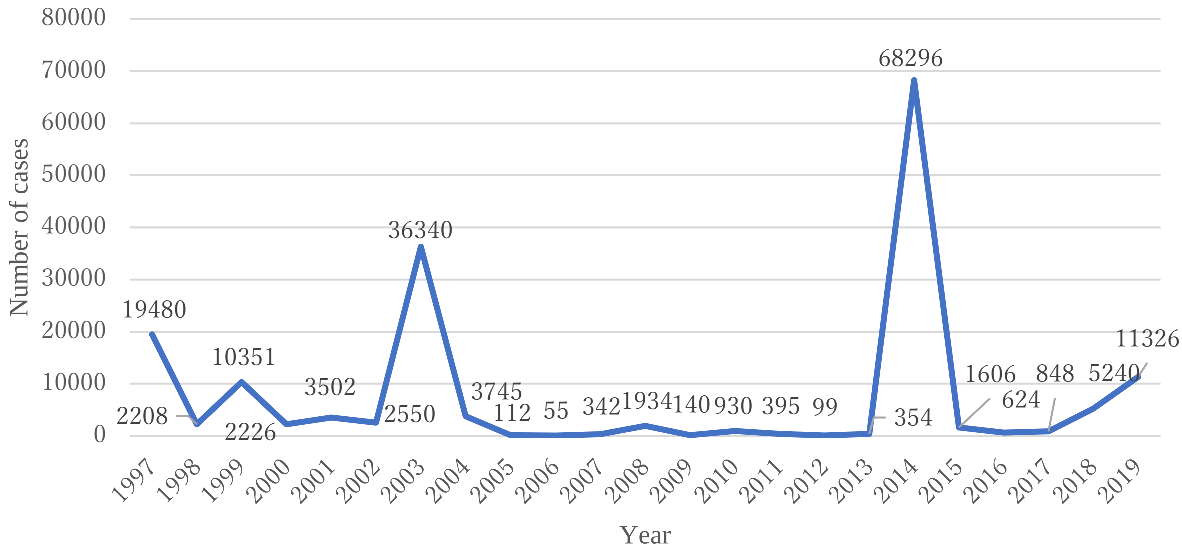


Figure 1.2 Reported cases of FMD in Sri Lanka
Source: Annual report DAPH, Sri Lanka

Cattle farming is one the most critical sources of living in the rural areas of Sri Lanka. The improvement of the cattle industry is a high priority in the in economic development (Ibrahim et al 1999a).

The advent molecular biology technology has enabled the genetic characterization of virus strains and thereby the tracing strains isolated from outbreaks can be carried out by with far greater accuracy than was possible until serological techniques (Knowles and Samuel, 2003). The result of the globalization, the spread of FMD outbreaks can change from local and regional spread to wide international spread, even to distance areas as occurred with the type O Pan-Asian lineage (Knowels et al., 2005; Cottam et al.,2006).

The patterns of excretion of FMDV during infection have been extensively studied, many modalities of transmission between animals have been described (Alexandersen et al., 2003). The sporadic and country wide FMD outbreaks have been reported in many parts of the world mainly developing countries including India and Sri Lanka (Biswal et al., 2012; Di Nardo et al., 2011).

The serotype O is the most virulent form that that significantly reduces the profit margin of cattle industry (Subramaniam et al., 2013b). Serotype further divided into topotypes which are defined as genetically and geographically distinct genotypes. The critical threshold for topotype differentiation is 15% nucleotides divergence in the VP1 genomic region (Knowles and Samuel, 2003). The serotype O has 11 topotypes including Middle East-South Asia (ME-SA) which is the most widespread topotype in South Asia (Jamal and Belsham, 2013). A topotype further divided into lineages at critical threshold of 5% nucleotide divergence (Knowles and Samuel, 2003). Ind-2001 and Pan Asia-2 lineages of the topotype ME-SA are frequently reported in India (Brito et al., 2017).

The availability of literature on FMD epidemiology and risk factors, the outbreak occurs each year cause severe damage and threat to development of livestock industry in Sri Lanka. Regulate the animal disease act to control of animal movement is the key factor. One of the most effective ways for the eradication of FMD is the prevention of the transmission of outbreak in the country.

1.2.2 Socio-economics of FMD

World Animal health organization (OIE) officially recognized FMD status for purposes of trade. The OIE recognizes 68 countries as FMD free with vaccination and 12 countries that have FMD free zones without vaccination. Also recognize 12 countries free with vaccination and free zones where vaccination is practiced in 8 countries (OIE, 2020). In FMD endemic countries, mainly developing countries, the disease threatens food security and the livelihoods of small holders and prevents animal husbandry sector from developing their economic potential. FMD has been eradicated by many developed countries but remains endemic in most of the world. When FMD outbreaks occur in disease free countries and zones that produce livestock for export economic impact is clear (Knight-Jones and Rushton, 2013). Even FMD cause low mortality the frequency of outbreaks and large number of animal species effected in each outbreak lead to impact for FMD in endemic countries (Onono et al., 2013). Animal movements and trade play a key role in the spread of FMD. Hence, despite the significant economic losses involved (James and Rushton, 2002), movement and trade restrictions at domestic and international level are main tool to control (Sutmoller et al., 2003). FMD affects main livestock species causing high morbidity and low mortality, but high death in young animals (James and Rushton, 2002; Perry and Randolph, 2003; Perry and Rich, 2007; Perry and Sones, 2007; Perry and Grace, 2009).

Production losses due to reduced milk production (Bayissa et al., 2011), affecting both the calves and humans that depend on it and cause 33% of losses in endemic settings (Ellis and Putt, 1981). This not only important to commercial dairy operations milk is an important source of nutrition many pastoralists, particularly for children (Catley et al., 2008). FMD has short term effect on cattle health, chronic FMD typically reduces milk production by 80% (Bulman and Terrazas, 1976; Bayissa et al., 2011). Growth rate of young animal suppressed by 2% to 3% (Rufael et al., 2008) sometime more than this (OIE/Iowa University, 2007). Loss of draft power of animal for agriculture purpose (Ellis and James, 1976; Perry et al., 1999; Perry and Randolph, 2003). FMD also can cause abortion, and farmer loss the calf and keep the cow for another year or more, or cull the animal. Visible production losses are most remarkable in pigs in intensive system and dairy cattle which are important source of animal protein in developing countries (Delgado et al., 1999).

Due to abortion, causes infertility and problem of conception rates need to have higher proportion of breeding stock. This invisible loss means that for every kilo of milk and meat produced there is an additional fixed cost to maintain more breeding animals. (Rushton, 2009). For the purpose of FMD control include vaccination, outbreak control, culling and compensation is born by tax payer. These costs estimated 2.35 billion doses of FMD vaccine administered in the world every year (Hamond, 2011) at a cost of $0.4 to $3 or occasionally $9 per dose including delivery and application (Sutmoller et al., 2003: Forman et al., 2009). Wildlife kept out of FMD free zones with fencing which is both costly and affects wildlife ecology (Gadd, 2012). FMD free countries involve to prevent to disease introduction, import controls and sometimes vaccination, also maintaining FMD early detection and control capability, including vaccine bank, FMD related researches (Knight-Jones and Rushton, 2013). However, costly outbreaks can occur in formerly FMD free countries. Striking examples are the cost of surveillance are significant, including providing disease freedom after an outbreak: more than 3 million serum samples were tested after the outbreak in United Kingdom in 2001. (Paton et al., 2006) in addition to approximately 3.5 million serum tested during the outbreak. Thompson et al (2002) estimated for control measures can affect other industries, in UK 2001 outbreak which caused US$ 4-5 billion in lost tourism revenue. Farmers oppressed due to culling based control method, can lead to wider impacts of depression and suicides (Mort et al., 2005). Mansley et al (2011) estimated for one third of animals culled in the UK 2001 outbreak.

There is exist a gap in socio-economic impact of FMD study in Sri Lanka. It is endemic mainly in the eastern part of northern and eastern provinces causing extensive outbreak lead to major epidemics which often affect other provinces too.

As previously stated, FMD causes significant economic losses in milk production as well as the loss of productive dairy animals. Farmers play a vital role in the country's economic development by ensuring food security and livelihood. As a result, this study is critical in focusing on the economic impact of FMD connected with various control options in Sri Lanka.

1.2.3 Knowledge, attitudes and practices (KAP) on FMD

The majority of the global poor people are poorly educated and live in rural areas. They are mainly engaged in agriculture sector, and more than half of the poor are children. Woman represent a majority of poor in most regions and some age groups. 70% of poor aged below 15 and no schooling or only basic education (World bank, 2018). Knowledge, attitudes and practices (KAP) are method of surveying to overcome misunderstanding and represent obstacles to the activities that for implement and potential barriers to behavior change (USAID, 2011). KAP study usually is conducted to collect information on the knowledge (i.e., what is known), attitudes on thought and practices (i.e., what is done) about specific topics of population. The study on knowledge for FMD in Kenya reveals, that a cross sectional study was conducted in Nakuru, to investigate farmers knowledge and risk factors for clinical FMD. The majority of respondents knew of FMD and 80.2% of them could correctly identify the disease based on their knowledge of clinical signs. 20.4% of farmers vaccinate their animal against FMD in previous six months (Nyaguthii et al., 2019). There are several studies on zoonotic diseases on KAP carried out to reveal gaps of knowledge, attitudes and attitudes related to risky practices (Hegazy et al., 2016: Arif et al., 2017).

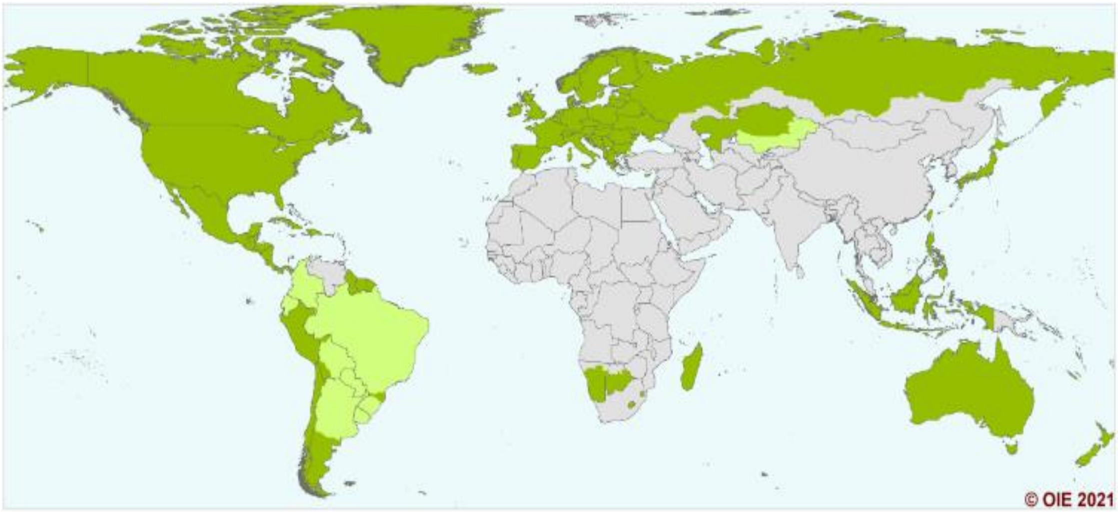
The study on KAP of cattle farmers regarding zoonotic diseases in Turkey, where cattle raising is the main occupation. 69.6% of the cattle farmers had information on anthrax, 62.8% on brucellosis, 18.4% on tuberculosis, 44.9% on rabies, 32.5% on Crimean-Congo hemorrhagic fever, 8.9% on hydatid cyst, 8.0% on toxoplasmosis and 7.9% on giardiasis. The results revealed that the increase in education, size of the enterprise, income of farmers related to an increase in KAP regarding zoonotic diseases (Özlü et al., 2020). KAP associated to brucellosis in livestock owners of Jordan revealed that 100% of farmers were aware of brucellosis, 87% indicated at a high risk if consumed unpasteurized milk. When brucellosis suspected, basic hygiene management practices are frequently degraded by farmers (Musallam et al., 2015). Risky practices of drinking raw milk is a source of transmission of brucellosis from animal to human (Young, 1995). The study confirms in Pakistan that the level of formal education is associated with the knowledge of brucellosis and the practices association with disease and the results were explained 97% of farmers not aware of mode of transmission of brucellosis, 66% of farm families consume raw milk, 49% live in shared animal house and not cover hand wound during handle with animals is 74% (Arif et al., 2017). Framers with no or poor educational level were less practice to have good management and more risk of contracting brucellosis in Yemen (Al-Shamahy et al., 2000) and Tajikistan (Lindahl, 2015). The study examined livestock farmers' knowledge of biosecurity along the border village of South Africa and Botswana, revealed 96% of farmers have no access to market farmers personal and farm characteristics were related to farmers' knowledge of bio security practices. Skilled labor tends to have better knowledge of bio security than unskilled labor (Oladele, 2013). Knowledge and behavior of cattle and sheep owners regarding FMD in Algeria, the results showed that they knew the clinical signs of FMD and mentioned fever (70%), salivation (65%), lameness (65%) and vesicles (51%). 42% of farmers implementing measures to prevent FMD and 58% did not take any preventive control of disease (Baazizi et al., 2019). Best farmers have been promoted as a superior extension tool for teaching farmers about the intervention (Millar and Photakoun, 2008).

The changes in behavior of livestock owner was determined by efforts to enhance public awareness of bio security measures by the training of traders, person in livestock industry, and both commercial and smallholder farmers (Windsor et al., 2011). The significant improvements in farmer knowledge and attitudes were recorded in southern Cambodia through participatory applied field research, on the job training and formal training program (Nampanya et al., 2012). Factor affecting farmers' KAP and contributing to FMD are underestimated in developing countries. Therefore, it is critically important to describe the KAP research gaps of FMD and social and farm factors influencing FMD epidemic among dairy farmers, as well as identifies potential risk factors in Sri Lanka.

1.2.4 FMD control measures and eradication policies

The control and possible eventual eradication of FMD is a major challenge for many countries under SEACFMD project (OIE, 2007, Windsor, 2011) for the sustainable farm and economic growth. The wide range of host, epidemiological complexity, movement of animals and animal products in the international market, high infectivity rate, emergence of new variants, interaction between domestic and wild animals, lack of highly potent vaccines, and lack of required infrastructure are the key factors that obstruct the control and eradication of FMD in endemic areas (Paton et al., 2009). The regional TAD control, with Republic of the Philippines having achieved World organization of Animal Health (OIE) certification of FMD freedom with vaccination (Figure 1.3). The disease control strategy applied in Philippines including quarantine animal movement controls, strategic vaccination, surveillance and investigation on FMD and also increases public awareness among farmers (Windsor et al., 2011).

Compulsory vaccination with strict hygiene management practices has been successfully implemented for the control or the eradication of the FMD in Europe and South American countries (Paton et al., 2009; Kamel et al., 2019). Depopulation of FMD infected and in-contact animals is preferred over introduction of vaccination in countries that are free of FMD. However recently, a "vaccinate to live" policy has also been considered in countries that are free from FMD due to social issues involved in large scale culls (Parida, 2009). In Netherlands, the "vaccinate to kill" policy was adopted, where infected animals were vaccinated followed by killing, when outbreaks subsided. The action produced quick control over the complete "test and kill" policy (Segundo et al., 2016). The test and killing policy are not being considered in developing countries due to socio-economic issues (Pattnaik et al., 2012). The OIE and Food and Agriculture Organization (FAO) of the United Nations recommends the progressive control pathway (PCP) a staged approached for the control of FMD in endemic countries. FMD-PCP consists of stages from 1 to 5 for successes reduction, elimination, and eradication of FMD (Sumption et al., 2012).



Members and zones recognized as free from FMD without vaccination

Members and zones recognized from with vaccination

Countries and zones without an OIE official status of FMD

Figure 1.3 Global status of FMD
Source: OIE, 2021

Vaccination was the most frequently reported measures against FMD, restricting the disease animal with other cattle by keeping in the farm compound. In Kenya, most of farmers reported doing nothing to prevent FMD spreading in their livestock, due to lack of knowledge, perceived low risk of disease or not follow the recommended preventive measures (Nyaguthii et al., 2019).

Quantifying and deploying effective vaccination coverage at a population level is an essential component of FMD control in an endemic setting area. Uncertainty in vaccination coverage estimate could be address through improved record keeping including the use of vaccination record cards are recommend by FAO-OIE post vaccination monitoring guidelines (Ferrari, 2016).

Farmers must have knowledge and good attitudes to disease prevention. Vaccines have proven to be the most viable option for disease prevention. Effective communication between farmers and veterinarians could play an important role in achieving maximization of vaccination strategies (Hall and Wapenaar, 2012). Veterinarians' role in promoting awareness of a need to vaccinate the cattle. The study identified farmers were responsible for disease control and vaccinate their animal in the farm, there was some responsibilities placed on veterinarians (Richens et al., 2015), this evidence highlighted the need for an improved vet-farmer relationship as well as changing role of the vet in food production and animal welfare (Statham and Green, 2015).

Successful vaccination programs prevent major epidemics of an infectious disease by establishing "herd immunity" which results with few susceptible remain in the population to sustain disease transmission (Anderson and May, 1991; Nokes and Anderson, 1992). The common livestock species in Sri Lanka are cattle, buffalo, pigs and goats. The few numbers of sheep farm are available. As an OIE member country Sri Lanka has been identified to be in stage 1 of the PCP-FMD (FAO/OIE, 201). Stage 1 of PCP includes the identification of risk factors and the self-assessment questionnaire to understand the socio-economic impact of FMD which enable them to formulate a strategic control plan at stage 2 (Figure 1.4). The FMD control plan foresees in vaccination twice a year in endemic areas. Production of a local vaccine to one third of the national needs and remaining monovalent vaccine import from India. To improve the awareness on FMD suggests, enhancement of animal identification system, awareness program among political and religious leaders and welfare activists also upgrading the regulations for animal disease management. The free vaccine is provided by government for the control of FMD in Sri Lanka.

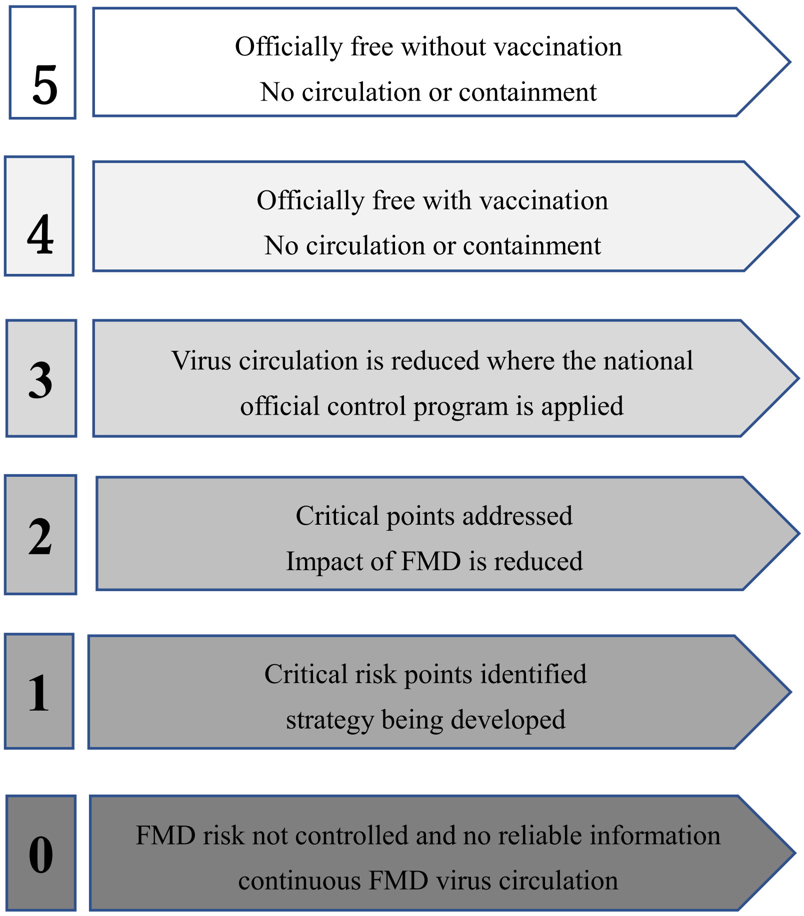


Figure 1.4 The progressive control pathway for FMD
Source: OIE, FAO

The PCP-FMD control pathway describes the steps involved in FMD control in endemic regions. Regular FMD immunization is critical to the success of the disease eradication program. Farmers' vaccination behavior on participation and satisfactory vaccination coverage is critical, but it has received little attention in FMD-endemic countries. It is important to explored the social and farm elements influencing farmers' vaccination behavior in order to increase participation in the FMD vaccination campaign in order to conduct effective mass vaccination in Sri Lanka.

1.2.5 Farmers' embedded behavior and adoption of sustainable control

The adoption of sustainable strategies is affected by several personal factors, which can be divided into benefits (i.e., beliefs positively affecting behavior) and barriers (i.e., beliefs negatively affecting behavior. From historical perspective, policy makers, researchers, and veterinarians assumed that farmers' decisions were entirely based on logical, technical and economic decisions (Burton, 2004). Livestock farming is a livelihood support, thus external factors, such as market price, customer demands, costs and returns, influence the decision-making process (Ellis-Iversen et al., 2010; Valeeva et al., 2007). Livestock farming is interlinked with lifestyle and often associated with family, and decisions can be explained through personal characters of the farmers' social environment (Jansen et al., 2009). Low level of on-farm adoption of recommendations to decrease disease transmission or enhance hygiene practices, urged for a better understanding of farmer behavior (Ritter et al., 2017). Personal traits frequently explain more variation in farm performance than farmers' management practices (Van Den Borne et al., 2014). The main purpose of social epidemiology is identifying the traits in order to explain and predict farmer specific behavior, which mainly consist of socio-psychological factors (attitudes, norms, perception) acquired from human behavioral and psychology. The incorporation of socio-psychological theories and methodologies with traditional epidemiological approaches has been proven useful for exploring livestock farmers' intention and behavior. The commonly used theories are the theory of planning behavior (TPB) (Ajzen,1991) and the health belief model (HBM) (Rosenstock et al., 1988).

TPB is socio-psychological theory to predict and explain specific behavior (Ajzen, 1991) TPB explain (Figure 1.5) human action is guided in three consideration: degree to which implement of the behavior is evaluated positively or negatively is called attitude, the perceived social pressure to engage or not to engage in behavior is subjective norm and perceived own capability to successfully perform the behavior is perceived behavioral control. All these lead to intention as positive or negative behavior. Given adequate actual behavioral control, people will perform their intentions. Actual behavioral control considers the availability of required prerequisites in terms of capital, knowledge, skills and opportunities. The positive results of intention are not always the execution of behavior to people's perception.

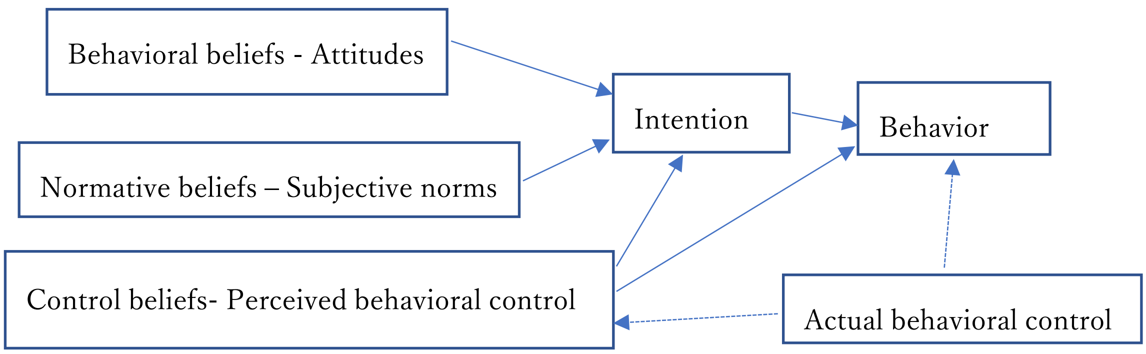


Figure 1.5 The Theory of planned behavior
Source: Ajzen, 1991

Adoption studies that investigate farmers' and veterinarian's belief, perception, intended behavior and actual behavior related to specific or broad animal health issues. Whereas the results of such studies are useful to suggest interventional studies that could actually change animal health management behavior (Huttner et al., 2001, Stringer et al., 2011). Knowledge has been shown its ability as fundamental motivator to comply with recommended behavior (Schemann et al., 2012).

The HBM describe (Figure 1.6) that people's beliefs about health problems and related treatment programs describe the engagement in health upgrading behavior (Janz, and Becker, 1984). The mechanisms behind the HBM are similar to those of the TPB, with the addition of health specific factors, such as perceived susceptibility. The implementation of such models gives a more structured view and justified prediction of farmer's behaviors.

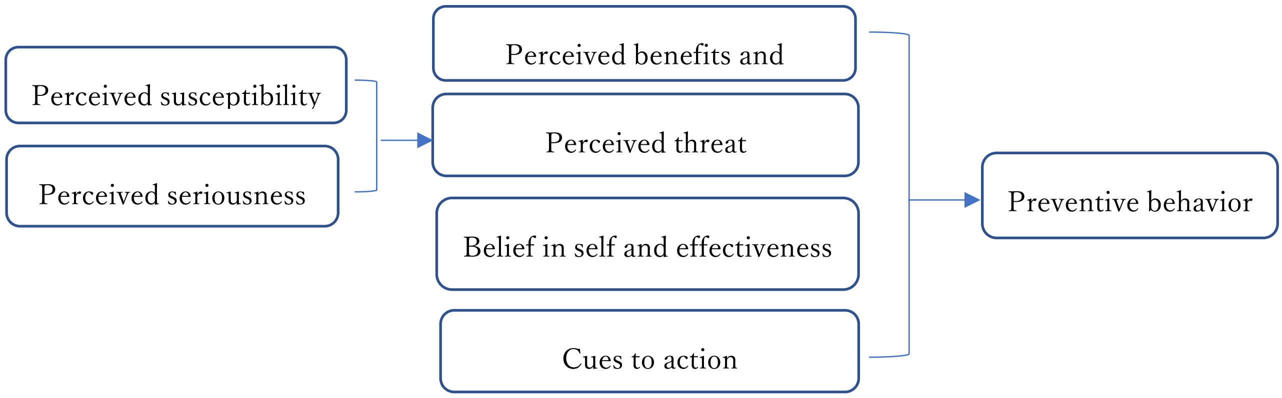


Figure 1.6 Framework of the health belief model
Source: Jansen and Lam, 2012

These applications have been used to analyses a wide range of animal health related behavioral issues for the control of mastitis (Jansen et al., 2010), Johne's disease (Ritter et al., 2016), FMD, (Delgado et al., 2014), lameness, practice of biosecurity, antibiotic usage and implementation of vaccination strategies (Richens et al., 2015; Sok et al., 2016).

The incorporation of farmers' good behavior is quite helpful in the control of animal diseases. Farmers in rural farming systems adopted different behavioral practices to treat and prevent animal diseases without notifying relevant authorities, which exacerbated disease outbreaks in other areas. Identifying distinct farmers' traditional behaviors during an FMD outbreak and changing their engrained behavior is important. Therefore, it is crucial to discuss the famers' embedded indigenous behavior and motivates them to adopt an appropriate FMD control approach in Sri Lanka.

1.2.6 Asymmetry information and externalities

In term of economic, theory of asymmetry information was developed as a plausible explanation for market failures. It proposes that an imbalance of information between buyers and sellers can lead to market failure. One party is well informed than other one described as asymmetry information (Schieg, 2008). Information asymmetry arises in a market if all parties do not have the same information, that is one party is more informed than another. Two types of information symmetry: hidden action and hidden information. Hidden action means to situations where an agent can choose between various actions. One agent does know the actual choice of first agent. Informed agent is inclined to report false information about real action to the unformed agent called moral hazard (Mrsic, 2017). Moral hazard refers to situation where agent can undertake decision that principal cannot monitor. The principal agent framework to examine livestock animal disease management in the presence of potential moral hazard and adverse selection (Hennessy and Wolf, 2015).

Information asymmetry well known studied in international trade mention that foreign investors have an informational advantage than local traders due to more experience in trading (Bae et al., 2011); and in banking (Boateng et al., 2018) also in control of animal disease (Hennessy and Wolf, 2015). Direct cattle sales overcome the problem of asymmetric information, because the buyers more likely wanted to buy vaccinated cattle from direct sellers (Chymis et al., 2007).

Veterinary authority and livestock farmers engage in disease control simultaneously. DAPH involve to prevention and control of diseases by implementing regulations while farmers maintain herd health and may exit gap in information between farmers and animal health authority. Farmers could be sold the disease animal to another farmer without providing correct information (hidden action), because knew more information about disease (Hennessy, 2007). The information gap between farmers (agent) and the government (principal) lead to asymmetry information or hidden knowledge (Laffont and Martimort, 2001).

The presence of FMD creates problem to all livestock owners in particular region. The externalities of FMD outbreak occurs because of one farmer did not protect his animals' other animals may suffer. In opposite when livestock owner protects their animals from FMD infection they will generate a positive externality as they are less likely to infect to other farms (Knight-Jones and Rushton, 2013). If the farmers will not engage in control FMD, other neighboring farms at risk of FMD. Where externalities continue there is a need for public investment for others. These externalities are not equally contributing among all livestock sectors because the production loss higher in commercial dairy farms (Perry and Randolph, 2003). FMD cause loss in milk production, mortality, effect beef industry, weakness of animal and infertility which are describe as negative externalities. During FMD outbreak, some indigenous farmers practice their own way to treat FMD, during this behavioral practice there is a possibility of spreading FMDV other farms. This embedded practices also defined as negative externalities. If farmers vaccinate the cattle, they try to protect other farms as positive externalities.

In summary of literature on FMD integrated control study was extensively reviewed on epidemiology, risk factors for outbreak, socio-economic impact. The control of FMD possibilities were also reviewed on famers' KAP level, acceptable control measures and eradication policies in different countries. Furthermore, reviewed on farmers' behavior and asymmetry information were influenced on animal disease control. Therefore, this thesis explores the existing research gap of considering FMD epidemiology, socio-economic, farmers' KAP and behavioral characters for the integrated FMD control in Sri Lanka.

1.3 Objectives and structure of the dissertation

The general objective of this thesis is to clarify the present foot and mouth disease status and related farmers' behavior, provide inputs for integrated effective control strategy in Sri Lanka. Potential interventions are needed for the FMD control within the allocated budget. Based on the detailed literature review in previous section, dairy farmers' knowledge, attitudes and practices, FMD vaccination and farmers behavior towards FMD control were identified for the successful eradication in FMD free countries. This study endeavors to fill these gaps by generating a national level FMD control in cattle production of Sri Lanka. The specific objectives were to:

1) Identify the farmers' knowledge, attitudes and practices (KAP) of FMD
2) Explore the factors affecting vaccination behavior of farmers to control FMD
3) Clarify the famers' embedded traditional behavioral practices for the treatment and control of FMD

The thesis comprises of seven chapters. Chapter 1 explains the epidemiology, risk factors and socio-economic of FMD. Further it reviews the farmers knowledge, and embedded behavior for prevention and control of FMD. Chapter 2 describes the livestock production and issues in animal disease control in Sri Lanka, mainly consider FMD is the economically important disease. In relation to specific objectives, Chapter 3, 4 and 5 describes the results of analysis (Figure 1.7). Chapter 3 explains the farmers' knowledge, attitudes and practices in terms of different socio-farm factors (Corresponding with specific objective 1). Chapter 4 describes the farmers' knowledge affecting vaccination behavior for the control of FMD in Sri Lanka (Corresponding with specific objective 2). Chapter 5 describes the farmers' embedded behavior to approach sustainable disease control (Corresponding with specific objective 3). Chapter 6 explain the general discussion followed by chapter 7 conclusion based on combine results of analysis.

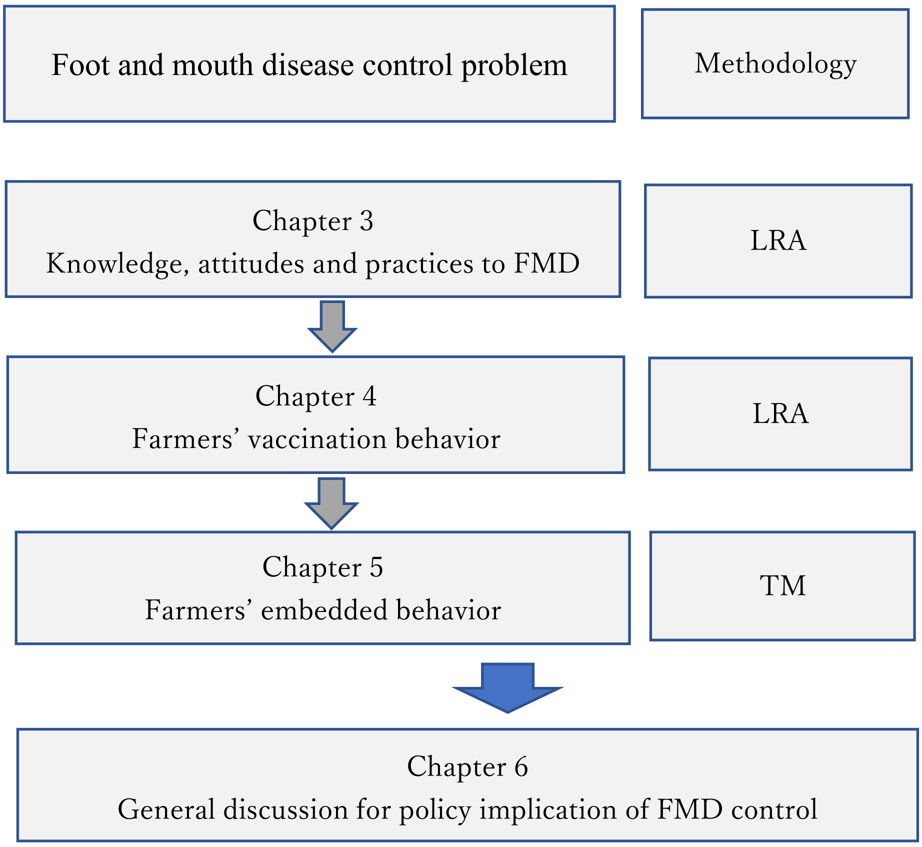


Figure 1.7 Schematic outline of the thesis
Note: LRA- Linear Regression Analysis, TM- Text Mining

1.4 Study area

1.4.1 Background and cattle farming system of the area

Sri Lanka follows a diverse socio-cultural tradition. There are different farming management practices, such as intensive and semi-intensive, and other extensively managed large herds, depending on the agro-climatic regions in the country (Kothalawala, 2011). Especially, the eastern province was selected as the area of study because of the high foot and mouth disease outbreak reported in the past (DAPH, 2014). The dry zone covers two third of the land area and around 75% of the total cattle and buffalo population (1.4 million) of the country. The study area of the eastern province consists of approximately one fifth of cattle and buffalo population (DCS, 2018). There are two established livestock management systems in the dry zone, namely the traditional management system (extensive system) in the villages and the semi-intensive or intensive system. In the traditional system, the farm's size tends to be medium with an average of 18.2 animals per farm, (Abeygunawardena et al., 1997) large with an average of 64.2 animals per farm (DAPH, 2009). Small herds of 6.6 animals per farm were kept semi-intensively or intensively. Livestock is the primary or most secondary income generation source for the majority (91.4%) of farmers in the traditional system and 51.5% in irrigated settlements (Abeygunawardena et al., 1997).

Ampara district of the dry zone was selected for this study because of the presence of different socio-cultural backgrounds with different livestock management systems, in addition to the high disease incidence (Wickramasuriya et al., 1983). The district of Ampara is in the southeast region of Sri Lanka and belongs to the eastern province.

1.4.2 Dairy farming and study population

The cattle and buffaloa in the eastern province are in large herd, the herd size between 15 to 20 animals seen in Batticaloa, Ampara and Trincomale districts under extensive management system. Table 1.2 shows the total cattle and buffalo population in the Ampara district is approximately 177,000 (EP, 2019). The government veterinary range is the smallest functional unit of the veterinary delivery system and consists of the number of villages. The land area of eastern province is 9,996 km^2 with 1,555,997 human population. The province contributes 15% of land area and 7.5% of the total population of the country (DCS, 2012).

There was a huge outbreak of FMD in all twenty-five districts during the period from January to December in 2014, and officially reported FMD cases of 68,296 led to 1,995 animal deaths due to this disease in Sri Lanka. Out of twenty ranges, sixteen veterinary ranges of Ampara district affected by FMD in the year 2014 and reported 4,727 cases and 105 deaths (DAPH, 2014). Kalmunai (KAL), Navithanveli (NAV), and Sammanthurai (SAM) ranges were devastated by FMD, therefore, these three areas were considered for the study. The ethnicity of these ranges was mainly Muslims and Tamils who engaged in livestock farming and their main language was Tamil (Table 1.3).

Table 1.2 Characteristics of dairy farming and milk production (Ampara district)

Veterinary range	Livestock population		Farm families (No)		Daily Milk production (Lit)	Milk collecting centers (No)
	Cattle	Buffalo	Cattle	Buffalo		
Addalachchenai	3850	2050	582	110	2330	-
Akkaraipattu	5125	2810	1042	112	2800	-
Alayadivembu	8647	8617	1442	101	143	1
Ampara	4800	620	859	20	5210	2
Damana	6189	616	1685	40	885	2
Dehiyathakandiya	7596	190	1638	25	4600	20
Irakkmam	1300	1600	175	77	1400	-
Kalmunai	1840	380	957	40	1005	-
Kalmunai (Tamil)	1937	705	1265	22	1133	-
Karaitheevu	2300	500	671	26	1900	-
Lahugala	4018	4482	741	161	980	-
Mahaoya	14500	1500	1490	13	6258	4
Navithanveli	7350	1950	2505	106	1500	-
Ninthavur	2620	512	393	25	2600	-
Padiyathalawa	6780	354	1992	3	1960	22
Pottuvil	4000	8000	1801	851	2911	3
Sainthamaruthu	215	330	99	8	370	-
Sammanthurai	7976	2137	1272	108	685	2
Thirukkovil	17247	10706	1862	319	17200	2
Uhana	19221	1626	3177	131	8871	10

Source: EP, 2019 - Statistical information, Eastern Province, DAPH

Table 1.3 Demographic characteristics of study area (Ampara district)

Veterinary range	Gramma Niladhari Divisions (No.)	Area (km^2)	Human population in Percentage (%)			
			Sinhalese	Tamil	Muslim	Other
Addalachchenai	32	61	5.8	1.8	92.3	0.0
Akkaraipattu	28	50	0.4	0.1	99.4	0.0
Alayadivembu	22	83	1.1	97.9	0.1	1.0
Ampara	22	174	98.7	0.4	0.3	0.5
Damana	33	538	99.5	0.1	0.3	0.0
Dehiyathakandiya	13	383	98.4	0.1	0.7	0.8
Irakkmam	12	75	6.6	2.5	90.9	0.0
Kalmunai	29	22	0.4	0.3	99.4	0.0
Kalmunai (Tamil)	29		0.8	89.6	8.0	1.7
Karaitheevu	17	7	0.2	59.0	40.2	0.7
Lahugala	12	815	93.5	6.5	0.0	0.0
Mahaoya	17	667	99.7	0.1	0.2	0.0
Navithanveli	20	67	1.0	64.9	34.1	0.1
Ninthavur	25	35	0.1	3.8	96.1	0.0
Padiyathalawa	20	379	99.3	0.2	0.5	0.0
Pottuvil	27	265	2.6	19.0	78.2	0.2
Sainthamaruthu	17	5	0.1	0.1	99.7	0.0
Sammanthurai	51	120	0.6	12.4	86.5	0.4
Thirukkovil	22	184	0.6	99.4	0.0	0.0
Uhana	55	485	99.9	0.1	0.0	0.0

Source: DCS, 2012; DCS, 2020

1.4.3 Sample size and data collection

The list of farm registrations available at the government veterinary office was used as the sampling frame, and farmers were randomly selected from three ranges in equal proportions of 60 samples. Random sampling was used to select 180 respondents for the study. This study was conducted among small and large-scale livestock farmers who maintained cattle and buffaloes. Cattle owners were selected from three veterinary ranges in Ampara district (Figure 1.8). The study was conducted for a period of one month in September and October 2019. Data was collected from farmers through a questionnaire on rearing cattle and buffalo, which took approximately 20 minutes per interview by "face to face" survey in their own language (Tamil). This questionnaire was used to collect all the required information for the purpose of the study. The questions concentrated mainly on social factors, farm factors, training programs, FMD vaccination, FMD outbreak, and the number of animals vaccinated for FMD.

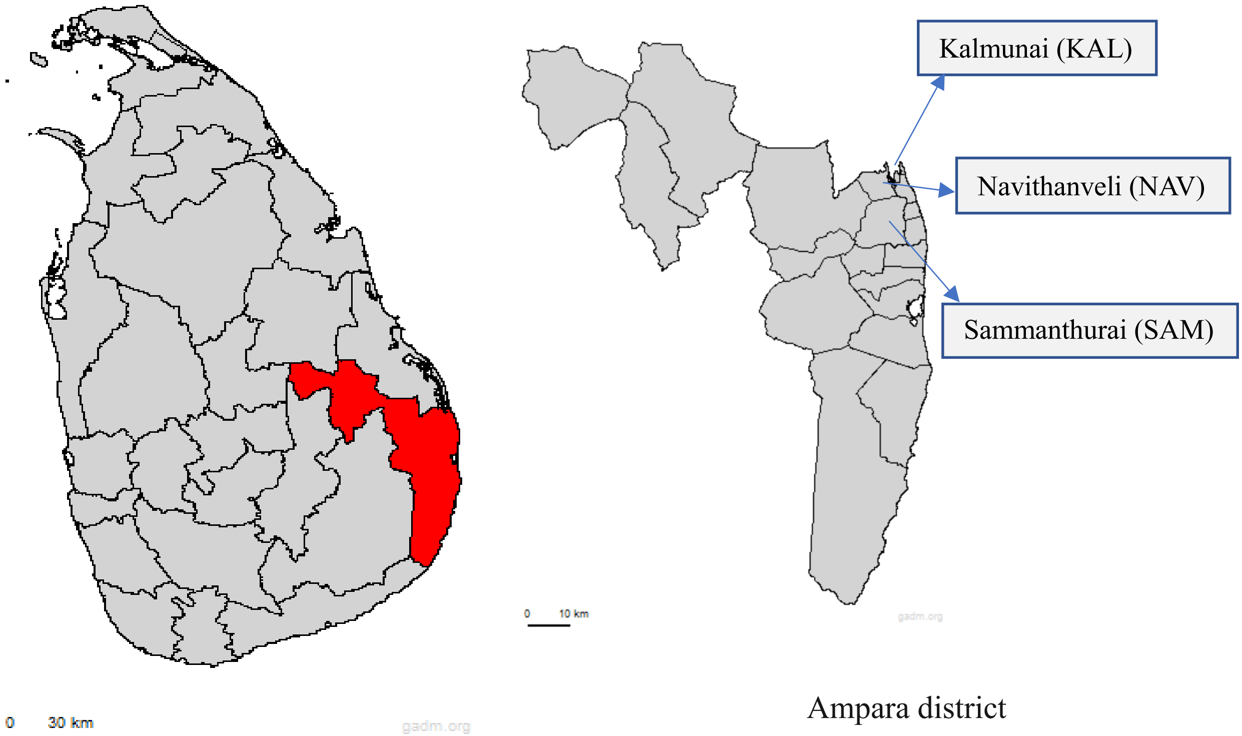


Figure 1.8 Map of study area

CHAPTER 2

Livestock production and animal diseases in Sri Lanka

2.1 Introduction

Sri Lanka is a tropical island located between the 5^0 55' to 9^0 51' of North latitude and between 79^0 41' to 81^0 53' of east longitude in the Indian Ocean with total land area of 65, 610 sq km near South India. The greatest length of the Island is 432 km while greatest breadth is 224 km (DCS, 2020). The administrative division of the of country is arranged from province, district and divisional secretariat (DS) to the village level. There are nine provinces, 25 districts and 331 DS in Sri Lanka. Gramma Niladhari Divisions (GND) is the smallest unit of the administration which include 14,021 GN division in the country (DCS, 2020). The country is divided into three main agro-ecological zones namely, low country, mid country and hill country based on elevation demarcated at 300 m to 1000 m above mean sea level. Also, climatic zone is divided into wet zone (> 2000 mm) and intermediate zone (2000-2500 mm) and dry zone (< 2500 mm) according to the rainfall pattern and altitude. There are two monsoons annually, the south-west monsoon from May to August and north-east monsoon from November to February (MMDE, n.d).

In Sri Lanka the extent of agricultural is around 2 million hectares and almost 75% of the agricultural land is under smallholdings and the balance under estates. The total number of estimated small holdings is about 1.8 million and of this 90% are less than two hectares in extent. About 70% smallholdings are engage in crop production and the remaining has a mixture of crop-livestock farming (Abeygunawardena et al., 1997).

Agriculture sector plays an important role of economy in Sri Lanka. Livestock and poultry are valuable sub-sectors in agriculture and produce milk, meat and egg in the form of quality protein. Cattle and buffalo had been reared as source of milk, draft power and manure as well as living bank to be used in times of need and large herd a symbol of wealth (Siriweera, 1982). Before the adoption of open economic policies in 1977, domestic milk production provided around 80% of the consumption needs of the country (Ranaweera, 2008). After the open economic policy, the consumption of dairy products increased dramatically. Figure 2.1 shows contribution of agriculture sector to Gross Domestic Production (GDP) was 7.0% which include 0.7% for livestock sector in 2019 (DCS 2020). Poultry sector is the major contribution among livestock industry, it contributed to 0.45% GDP which is 64% of livestock in Sri Lanka (DAPH, 2019).

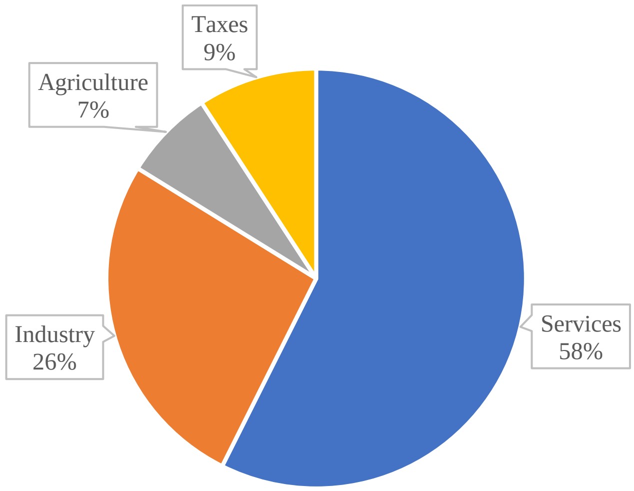


Figure 2.1 Share of GDP by major economic activities in 2019
Source: DCS, 2020 Economic statistics of Sri Lanka

2.2 Livestock production and management system

2.2.1 Livestock population and farming practices

The different roles played by livestock in the developing and developed countries is important to understand the impact of livestock on livelihoods, economic development and environment. Livestock production in developing countries occurs in diverse systems range from pastoral or grassland-based systems, which occupy more land area and lower human densities connection with mixed crop-livestock system. Crop and livestock farming accompany each other. Intensive systems mainly in urban areas. This livestock production systems in developing countries produced around 50% of beef, 41% of milk, 72% of lamb, 59% of pork and 53% of poultry (Herrero et al., 2009). Livestock involve multiple roles in supporting livelihoods mainly for the source of house hold income. National data from developing countries, 68% of households earn income from livestock (Davis et al., 2008). Livestock act as main assets of rural households possess. Access to control and ownership of assets are critical aspect of well-being (Carter and Barrett, 2006).

In Sri Lanka livestock plays an integral part of rural economy and providing livelihood support to the rural communities. Livestock sector contribute an important role for food and nutritional security, sustainable consumption, production and rural livelihood.

Livestock sector mainly consist of cattle, buffalo, goats, sheep, pigs and poultry. Dairy and poultry form majority of livestock sector in Sri Lanka. Total number of registered farms including poultry is around 0.6 million in 2019 (LSB, 2019). Total livestock farmer population is about 0.7 million, with livestock activities contributing 30-60% of their gross farm income (Perera and Jayasuriya, 2008). Dairy farming is a major components of livestock industry. The data indicate in figure 2.2 cattle and buffalo population in the country as 1.52 million and 0.47 million respectively in 2019 (DAPH, 2019). Among livestock population, cattle and buffalo contribute 56% and 18% respectively whereas goat 20% and pig 6% in year 2019 (Figure 2.3). The highest number of cattle populations were recorded in Kurunagale, Anuradhapura and Batticaloa districts, whereas the highest number of buffalos was reported in Hambantota, Batticaloa and Trincomale districts (LSB, 2019). The dairy farming is mostly contributed by smallholders, mixed crop livestock operation (Bandara, 2000) and 75% of local milk production comes from smallholder farmers in Sri Lanka.

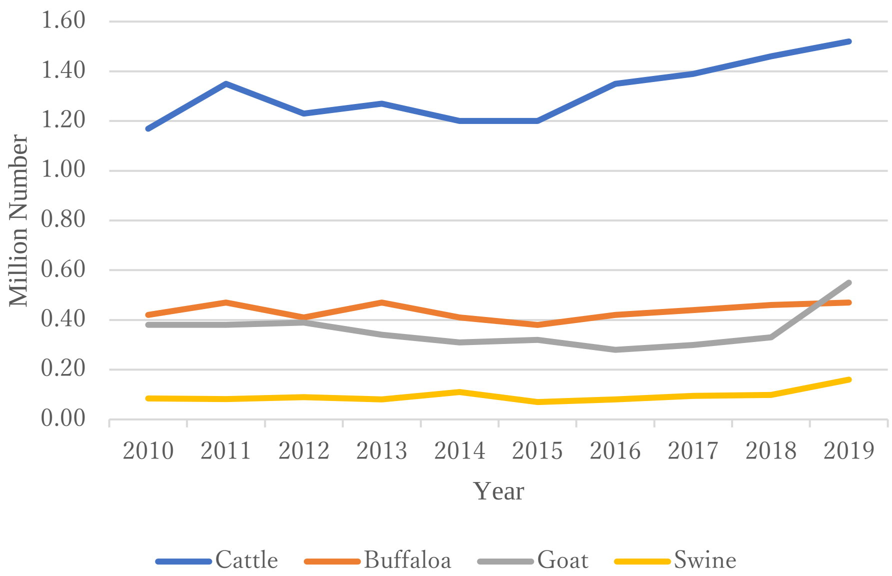


Figure 2.2 Livestock population in Sri Lanka
Source: DAPH, Sri Lanka

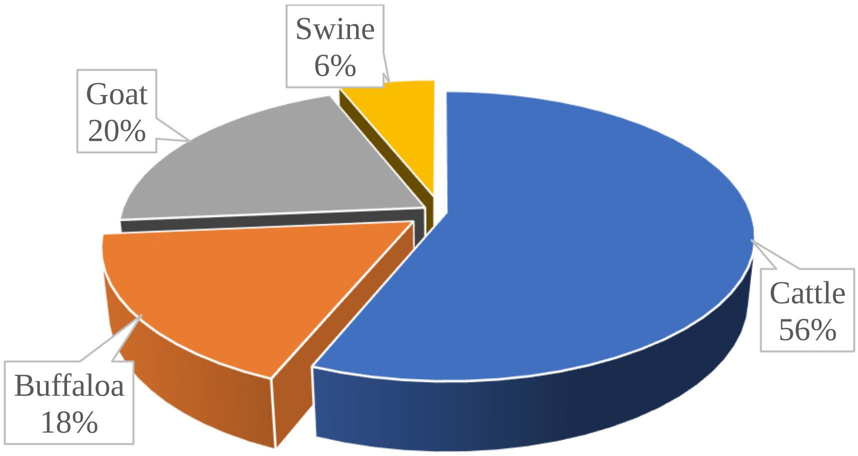


Figure 2.3 Livestock population in percentage composition
Source: LSB, 2019

The total amount of registered cattle and buffalo farms were 307,180 and 25,338 respectively and also the eastern province the indicated as the highest number of registered cattle buffalo farms than other province, while least were situated in Sabaragamuwa and western provinces (Figure 2.4).

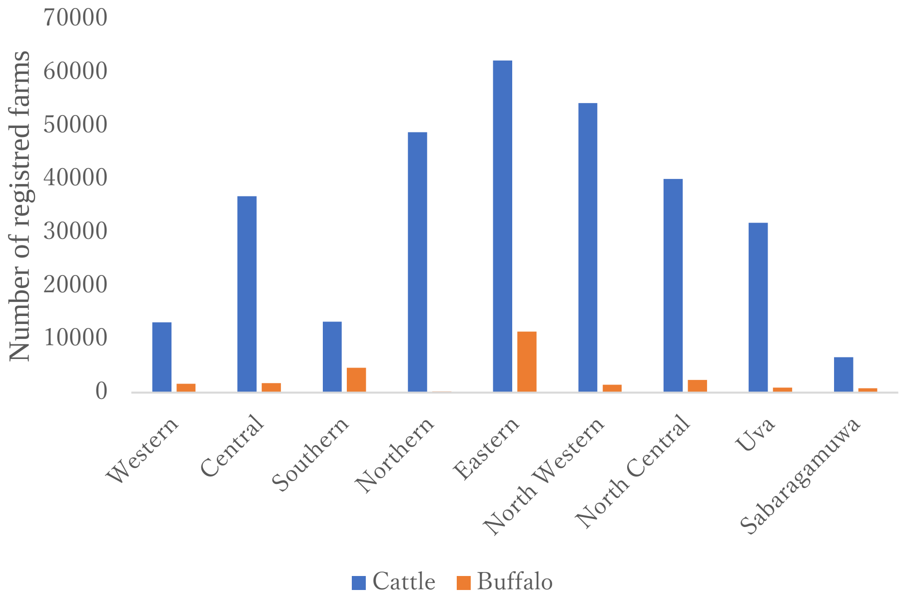


Figure 2.4 Provincial wise number of registered cattle and buffalo farms in 2019
Source: LSB, 2019

The cattle management system depending on agro-ecological zone, number of animals in the farm, availability of land and capital, type of breed and the productivity of animals and availability of feed resources. There are three different cattle management practices in Sri Lanka (Figure 2.5). In total 68% of dairy farmers managed under extensive system predominantly in eastern province in dry zone where drinking water and feed is seasonal and experience severe shortages of feed during dry period of the year, therefore cattle herd movement is observed from one area to another (Figure 2.6). Among intensive managed cattle farms, 36% are located in central province which zone of climate is wet and suitable for temperate breeds and their crosses. Around 50% of dairy farming under semi-intensive system which animals are free grazing in day time coming back to farmers place in night time shed.

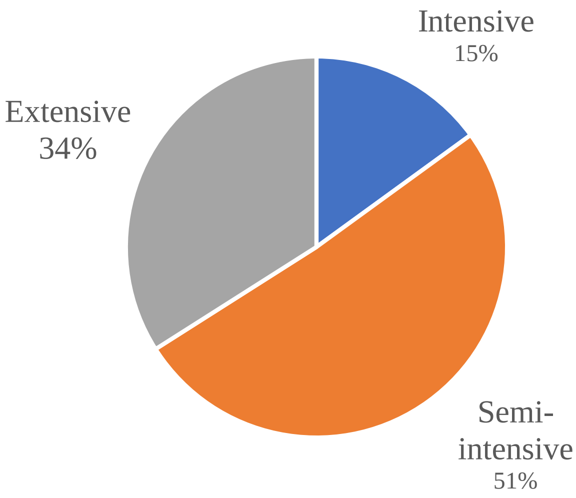


Figure 2.5 Cattle farm management system

Source: LSB, 2017

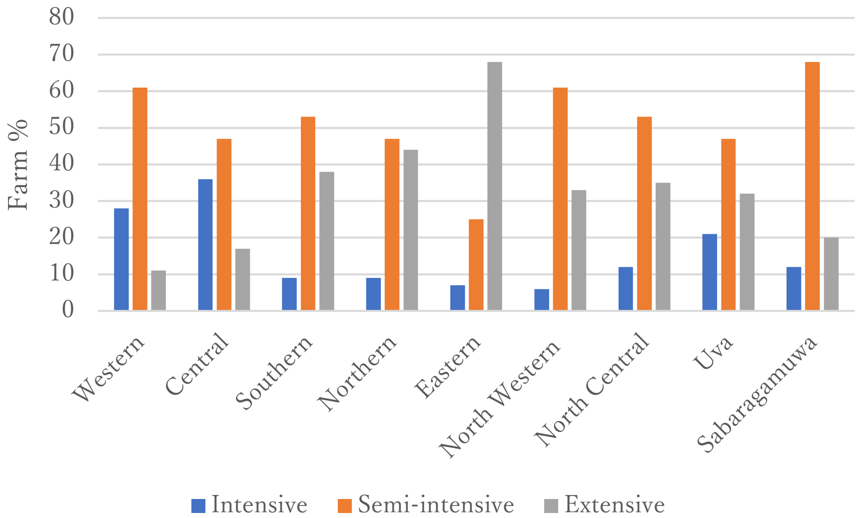


Figure 2.6 Provincial wise cattle farming practice

Source: LSB, 2019

According to the climatic zones the cattle management system further sub-divided. The features are given in Table 2.1

Table 2.1 Characteristics of cattle farm management system

Management system	Characteristics
Up country intensive system	Zero grazing with high level of concentrate feed
Mid country intensive system	Zero grazing with moderate level of concentrate feed
Wet and intermediate zone semi-intensive system	Tethered and or free grazing with limited concentrate feed
Intermediate and dry zone extensive system	Free grazing
Dry zone intensive system	Zero grazing with crop-livestock mixed farming

Source: Abeygunawardena et al., 1997

Smallholder dairy farming is a good income opportunity for crop-livestock farmers in mixed farming system lead to profitable and sustainable enterprises (Moran, 2009). The impact of national level animal production and productivity has been limited due to lack of understanding of ecological, socio-economic and cultural limitations intrinsic to the different agro-ecological zones (Zemmelink et al., 1999). Therefore, identification of the features of different management system will be help to motivate the national dairy production and make sure the sustainability of livestock farming.

The cattle breeds differ among topography and climatic zones. Indigenous local cattle, Indian breeds and their crosses and European breeds and their crosses are reared in farms 26%, 25% and 49% respectively (Figure 2.6) The European breeds and their crosses (86%) are dominate in mid country and hill country of central province (LSB, 2019). The main European breeds are Holstein Friesian, Jersey and Ayrshire are reared in Nuwara Eliya and Kandy districts whereas most of the indigenous local white cattle is reared in Batticaloa, Ampara and Trincomale in eastern province (LSB, 2019). Local cattle tolerate to harsh environmental condition with extensive management.

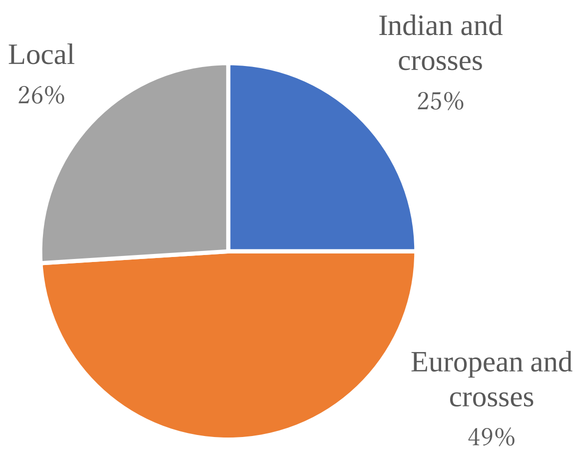


Figure 2.7 Types of cattle breed
Source: LSB, 2017

Also describe another category of cattle and buffalo production system according to the topography, climate and breed shown in Table 2.2

Table 2.2 Cattle and buffalo systems: Topography, climate and type of breed

Production system	Rainfall (mm)	Temperature (^{0}C)	Animal species
Hill country	>2000	10-32	Pure exotic and crosses
Mid country	>2000	10-32	Pure exotic and crosses, some Zebu cattle
Coconut triangle	1500-2500	21-38	Crosses of exotic breeds, Zebu types, indigenous, buffalo
Low country dry zone	1000-1750	21-38	Zebu types, indigenous, buffalo and their crosses, buffalo
Low country wet zone	1875-2500	24-35	Crosses of exotic breeds, Zebu types, indigenous, buffalo

Source: Ibrahim et al., 1999a and b

Most of the buffalo are rearing in dry and dry intermediate zones as medium to large herd manage under extensive and semi-intensive system. In wet and wet intermediate zones buffalo farming practice as semi-intensive and intensive system as small herds. Medium to large herds are under semi-intensive owned by state and private farms. Among the total buffalo population around 28% of animals are present in eastern province. The majority of buffalo belongs to local indigenous breeds, while others belong to Murrah, Surthi, Nili Ravi breeds and their crosses.

2.2.2 Livestock production

Livestock play different functions in agriculture, mainly, they provide crucial source of quality protein by producing milk, meat and eggs, further cattle and buffalo are a primary source of renewable low-cost draught power for various agricultural operations and transport. Other additional products include hides, skins and organic manure. Total national milk production was 414.8 million liters in 2020 of which cow milk and buffalo milk estimated 363.2 million liters and 51.6 million liters respectively. The milk production trend depicted in figure 2.8 from 2010 to 2020. Cow milk production has increased from 192 million liters to 363.2 million liters, whereas the buffalo milk production is not much change. The increase of milk production from 2010 to 2020 by 67.5% due to increase in cow and buffalo milk production. For the contribution of national milk production, central province is the highest, while the lowest from Sabaragamuwa province (LSB, 2019).

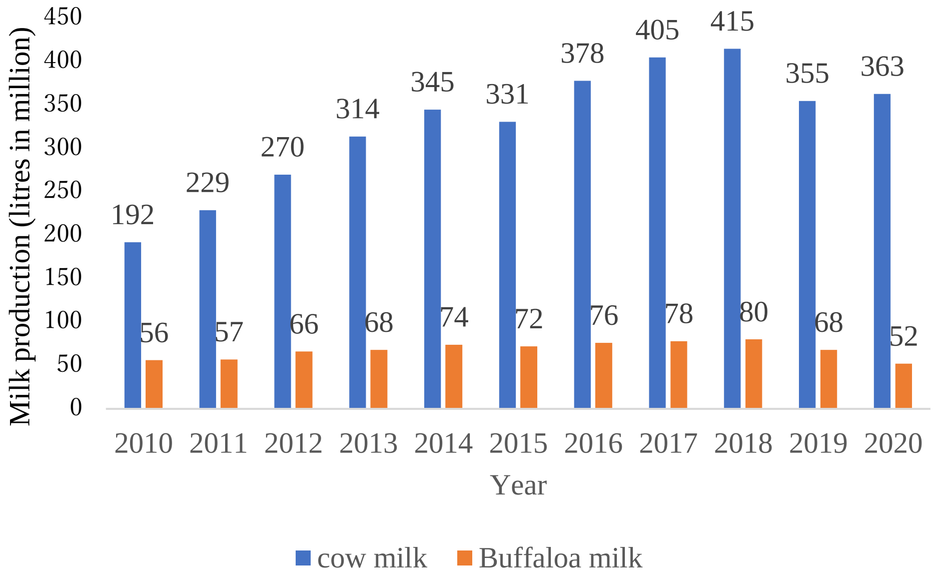


Figure 2.8 Annual milk production in Sri Lanka

Source: Key statistics of dairy industry, Livestock planning and economic division, DAPH, Sri Lanka

The domestic milk production was estimated 424.1 million liters, it showed 14% drop in milk production than previous year 2018. Total milk production is satisfying only 37% of total milk requirement of the country in 2019 (Figure 2.9). In order to fulfil the gap between the demand and supply for milk, annually import milk and milk powder and dairy products spending huge amount of money. Import of dairy products calculated to 98,837.8 metric ton in 2018 (DAPH, 2019). Among the dairy products full cream milk powder, skim milk powder and other milk products (cheese, butter) are important. In 2019 alone, the country has imported both whole milk powder and non-fat milk was 93,748 metric ton and spending SLR55.65 billion in 2019 (DAPH, 2019). The availability of local and imported milk including milk products had been amounted 51.1 liter per capita in year 2019 (DAPH, 2019). From 2009 to 2019, the total per capita availability had changed (Figure 2.10). It has increased by 47% from 2009 to 2019 due to domestic and importation of dairy production. To increase the local milk production suitable policy making, planning and implementation is necessary with an effective monitoring system is important to attain self-sufficiency in milk production.

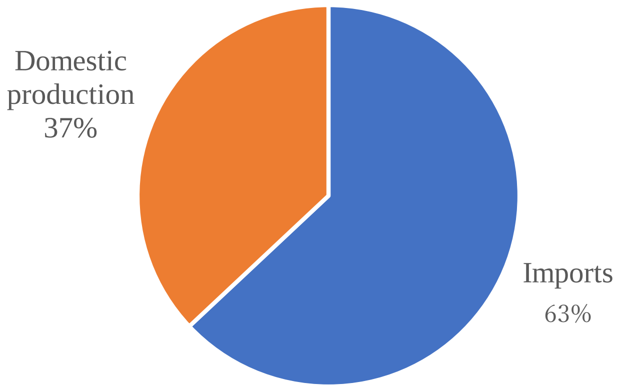


Figure 2.9 Milk market share
Source: DAPH, 2019

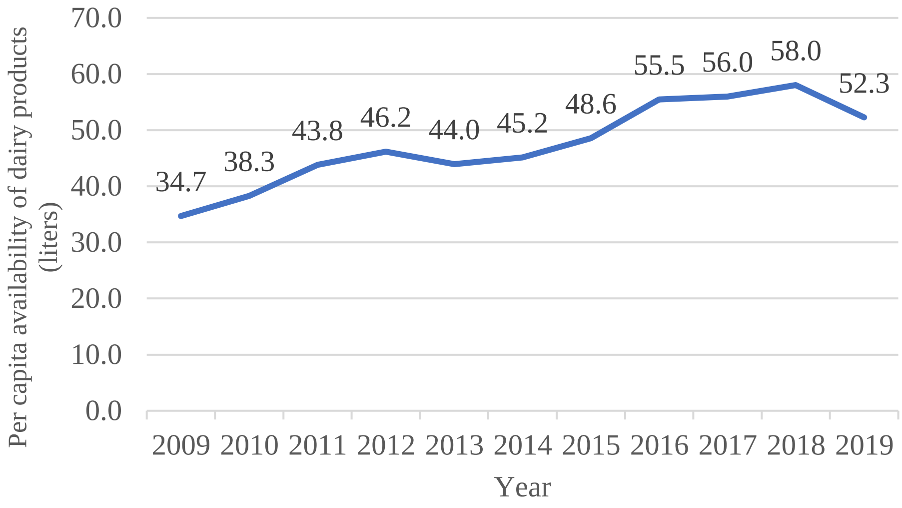


Figure 2.10 Per capita availability of dairy products
Source: AR and LSB, DAPH, Sri Lanka

The total milk production represents the amount of formal milk collection network by 315 milk chilling centers, out of this 67 are located in central province and informal market channels. The proportion is not included for family consumption or sold through informal market. The amount of milk collected by 14 main milk processors in the formal milk market is 243.4 million liters, around 30.4% of collected in the country from central province. Only 57% contribute to formal milk collection which comprised with public and private enterprises and small milk processors. The remain 43% of informal market is utilized by home consumption, local level private milk collectors, traditional dairy processors, retailers and hotels in 2019. The total milk production was 424 million liters in 2019, and only 44% collected by main milk collectors in 2019 (LSB, 2019).

The formal milk market includes farmer managed societies, dairy cooperatives and dairy cooperative unions. Farmers have to bring the milk to milk collecting centers where the collected bulk milk is stored under chilled condition. Each milk collecting have facilities to test the quality of milk and price of milk determine by percentage of fat and non-solid fat. If the quality of milk does not fulfil, will be rejected. The higher milk collected during 3rd quarter of the year, which 29.4% and lowest (22.3%) in 4th quarter of 2019. Places where the formal market is not available, milk is sold via informal market. The major part of informal milk is converted to vale addition processes, such as producing curd, yoghurt, milk toffee, ghee which improve the farmers' profit.

National Livestock Development Board (NLDB) farms, small- and large-scale private farms are the main milk producer in Sri Lanka. Among the milk collecting agent, MILCO Pvt is main channeled to formal milk market. To promote the better network, they have own Famer Managed Societies (FMS), collecting centers and chilling centers. Most of milk collectors have their own chilling centers and processing factories and average 75% milk collected will be processed in their factories (Vernooij et al., 2015).

The Full cream milk, non-fat milk, milk powder, ice cream, curd, yoghurt, ghee, sterilized milk, flavored milk, pasteurized milk etc. are the important processed of milk. This product distributed to whole sellers and retailers and end up with local consumers (Figure 2.11).

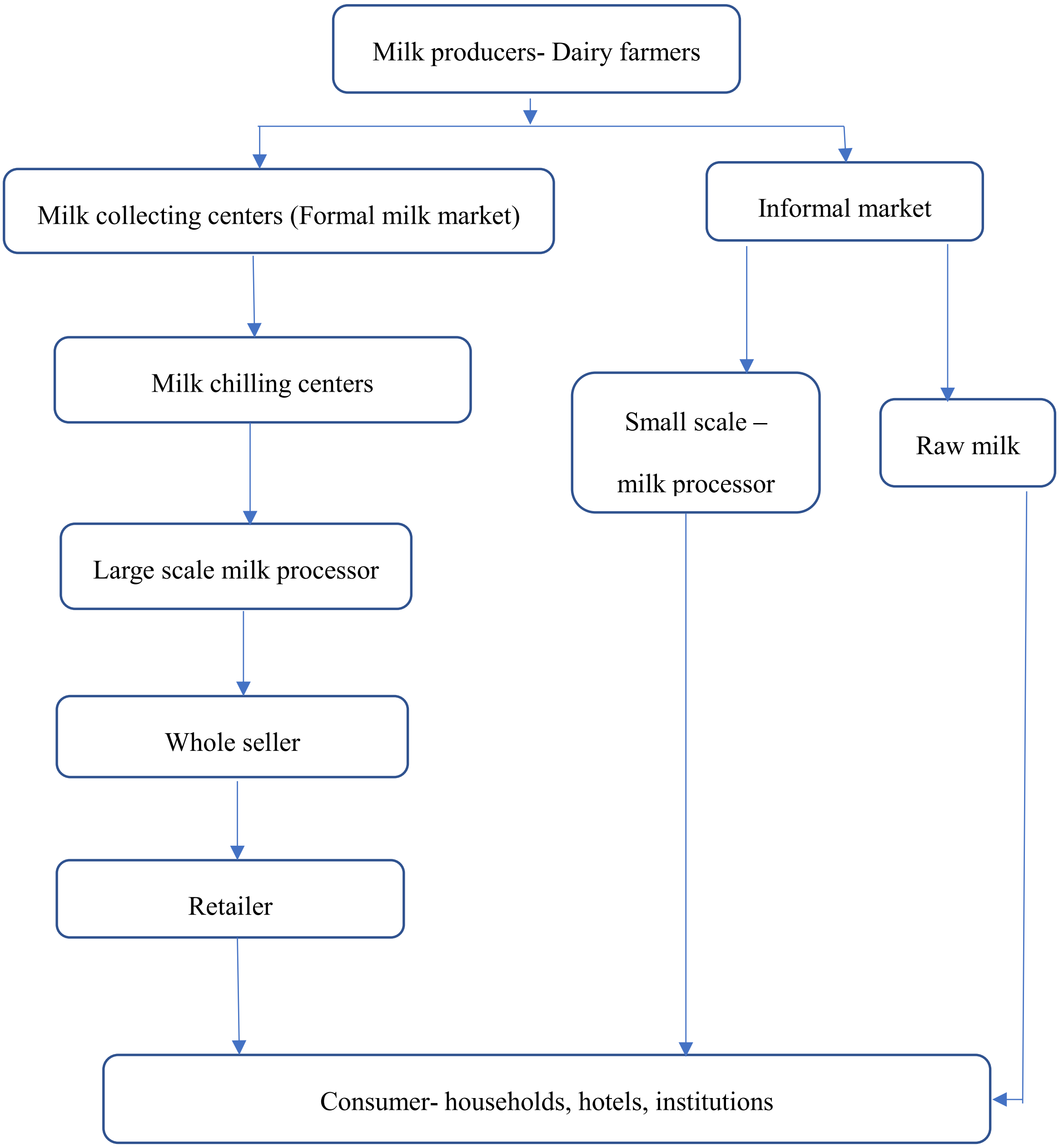


Figure 2.11 Flow chart of milk supply network in Sri Lanka

Source: LSB, 2019; Vidanarachchi et al., 2019

Import of dairy products to fulfil the gap between national milk production and requirement. The quantity of milk and milk products increased till 2018, and decreased in total dairy import in 2019. Importation of full cream milk powder and non-fat milk was decreased by 2% and 30% respectively in 2019. Dairy sector improvement to achieve the sufficient milk production through the adoption of genetic potential with artificial insemination, sexed semen usage, embryo transfer, introducing new breeding materials, pasture development program to produce good quality forage, establishment of animal feed plant, institutional support for loans, increase the farm gate milk price, improve the milk collecting network in rural areas and establish the milk processing plant.

2.2.3 Institutional infrastructure and policy support for livestock services

The institutional support is provided by government sector, public enterprises, private sector, co-operative sector and private sector institutions. The state sector is mainly engaged in providing public goods and distribution of inputs while necessary marketing facilities by private sector. The Ministry of Agriculture and Livestock is responsible for formulating policy planning and implementation, allocation of resource and monitoring. Department of Animal Production and Health (DAPH), Provincial Department of Animal Production and Health (PDAPH), National Livestock Development Board (NLDB) are the main public sector organization responsible of dairy development. Other government institution including Ministry of Agriculture, Ministry of Land and Environment, Central Environmental Authority, Mahaweli Authority, Coconut Research Institute, Department of Agriculture, Universities etc., directly involving in development of livestock sector in Sri Lanka (Ibrahim et al., 1999a and b).

The DAPH provides technical support for policy implementation, veterinary research, livestock and poultry vaccine production, preventive and curative animal health and disease control, animal breeding, ensure the animal feed and feed resources, human resources development, research and training, monitoring and evaluation of livestock projects and information sharing. Furthermore, DAPH act as legislative body to carry out disease surveillance, quarantine, assure the food safety of animal origin, introduce good farming practices, ensure the animal welfare and implementation of laws and regulations.

Central DAPH support technical advice and leadership to PDAPH and other livestock stakeholders. Livestock sector services supported through 337 government veterinary offices established all over the country. Veterinary offices are managed by veterinarians, functioning under PDAPH and strength the services to grass root level. Also responsible for implementing projects, supervising and evaluation livestock program, extension services, animal health services and knowledge sharing by farmer training. To establish the veterinary investigation network on animal disease prevention and control, 25 Veterinary Investigation Centers (VIC) have been established at district level.

Provincial DAPH in eastern province provide basic veterinary services to farmers in the aspect of establish healthy livestock population by treating sick animal and vaccination program, improve genetic quality of dairy animals by continuous artificial insemination, and extension services on farmer training, field visit to exposure the modern system of farm management, value addition of livestock products and efficient feeding resources. To enhance and improve the livestock activities among small and medium scale farmers in eastern province, there are facilities available such as regional livestock farm, regional training centres, value addition demonstration centre, animal breeding centre, goat genetic resource centre, goat farm, integrated model farm, buffalo nuclear herd and animal care centre.

Organizational structure of the DAPH has eight functional divisions, these provide technical and support functions. The divisions are animal health, animal breeding, human resource development, veterinary research institute, livestock planning and economics, veterinary regulatory affairs, administration and finance (Figure 2.12).

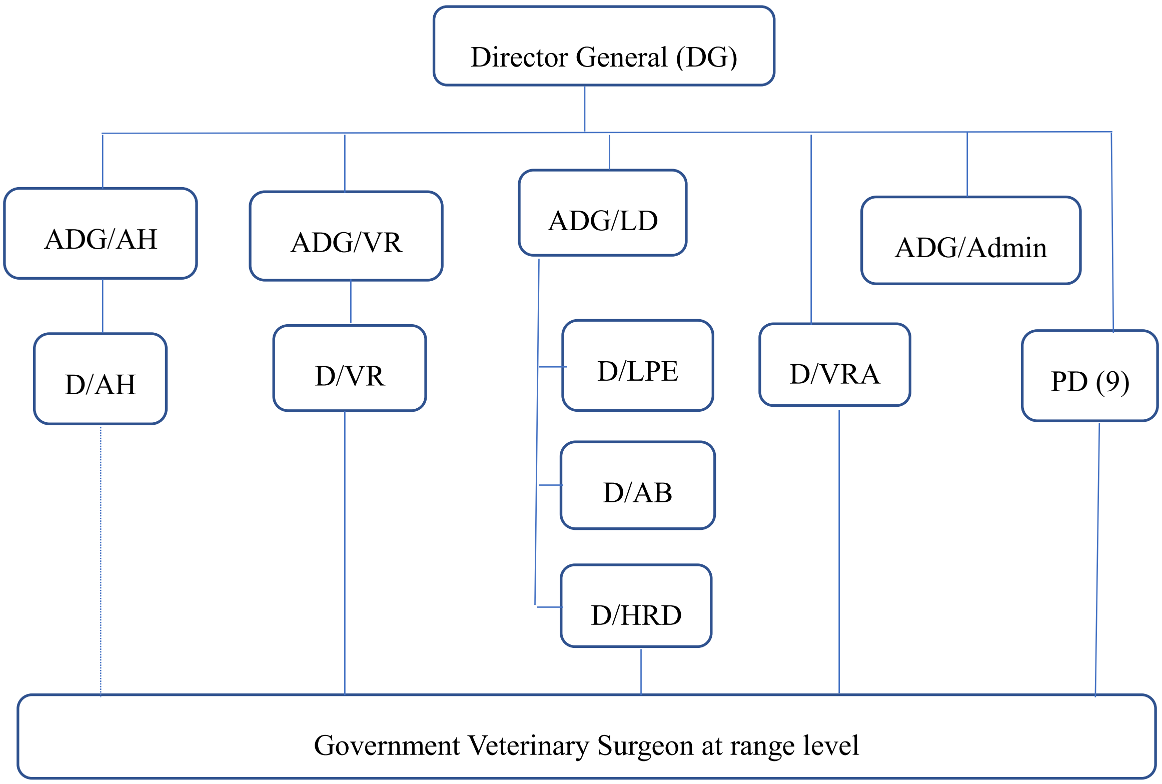


Figure 2.12 Organizational structure of the DAPH

Source: DAPH, 2019

ADG/AH- Additional Director General/Animal Health; ADG/VR- Additional Director General/Veterinary Research; ADG/LD- Additional Director General/ Livestock Development; D/AH- Director/ Animal Health; D/VR- Director/ Veterinary Research; D/LPE- Director/ Livestock planning and Economics; D/VRA- Director/ Veterinary Regulatory Affairs; D/AB-

Director/ Animal Breeding; D/HRD- Director/ Human Resource Development; PD- Provincial Director

NLDB which is under ministry of agriculture and livestock is a commercially oriented organization. The main function of NLDB farms is maintenance of nucleus herd of livestock and supply of breeding materials to the needy essential farmers. Also involve processing of livestock products and sales outlet. The Milk Industries of Lanka Company Limited (MILCO) is obtainment and processing of milk for value added products. MILCO provides institutional support for dairy farmer co-operative societies to improve their milk production by giving nutritional supplements for cow, training program and technology transfer information. The main function of Mahaweli livestock enterprise of the Mahaweli Authority of Sri Lanka (MASL) is responsible for promoting and popularize the livestock farming among settler communities in Mahaweli areas. There are different cooperative societies functioning to provide management and technical aspect, promote procurement of milk and milk value added products and motivate welfare schemes for society members. Samurdhi authority also involve in livestock and poultry promotion to uplift the livelihood, ensure the nutrition and poverty alleviation of the rural people.

There are private organization, which are involved in large scale procurement and processing of milk, packaging and marketing of milk products. Private companies in dairy sector are Nestle Lanka Ltd, Cargills, Newdale etc. are responsible for milk processing and marketing. These companies also provide welfare scheme for dairy farmers. The poultry sector mainly controlled by private sector and state sector involvement is low in poultry production. Poultry sector operation mainly in broiler meat, eggs, day old chick production, contract farming, manufacture and marketing of poultry feed. All Island poultry Association is the national organization for small and medium scale poultry producers and also poultry farmers are organized into regional societies. Large scale private companies involve in farming, hatcheries and animal feed and veterinary drugs owned by multi-national companies or individual companies.

2.3 Overview of livestock health and its control in Sri Lanka

2.3.1 Common livestock diseases

Animal diseases mainly categorize into infectious and non-infectious. Infectious diseases caused by bacteria, virus and parasites, and also some diseases occur by metabolic condition. In cattle and buffalo the important endemic bacterial diseases are Haemorragic Septicaemia (HS) and Black Quarter (BQ), while mastitis and brucellosis cause severe economic losses due to drop in milk production and mortality. Among viral diseases Foot and Mouth Disease (FMD) is highly contagious, causing economic impact on production lead to suppress the development of livestock sector in Sri Lanka. Gastrointestinal parasites such as nematodes, trematodes and cestodes also effect the production of animals. Babesiosis and Theileriosis are the blood parasitic diseases mainly effect pure bred European cattle and their crosses.

A) Foot and mouth disease (FMD)

Foot and mouth disease is causing high morbidity and less mortality of cloven-hoofed animals. FMD is the important notifiable disease in the OIE list in terms of prevention and control. It is endemic in eastern province causing extensive outbreak causing major epidemics which affect another province too. In year 2019 FMD was reported 11,326 cases with 83 deaths in 107 veterinary ranges in 18 districts (DAPH, 2019). The pattern of FMD epidemic starts with north-east monsoon. In dry zone, it related to animal movement in the extensive management system. The serious outbreak occurred in 2014 recorded more than 68,000 case and 1995 deaths in 20 districts (Figure 2.13). The highest number of FMD cases reported in Anuradhapura district from 2014 to 2019 out of 25 districts in Sri Lanka (Figure 2.14).

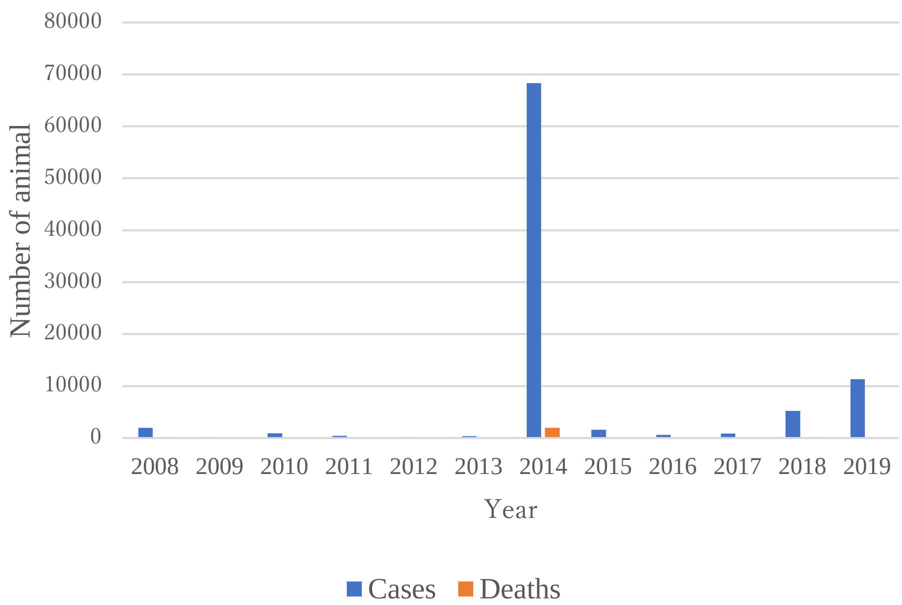


Figure 2.13 FMD outbreak
Source: AR, DAPH, Sri Lanka

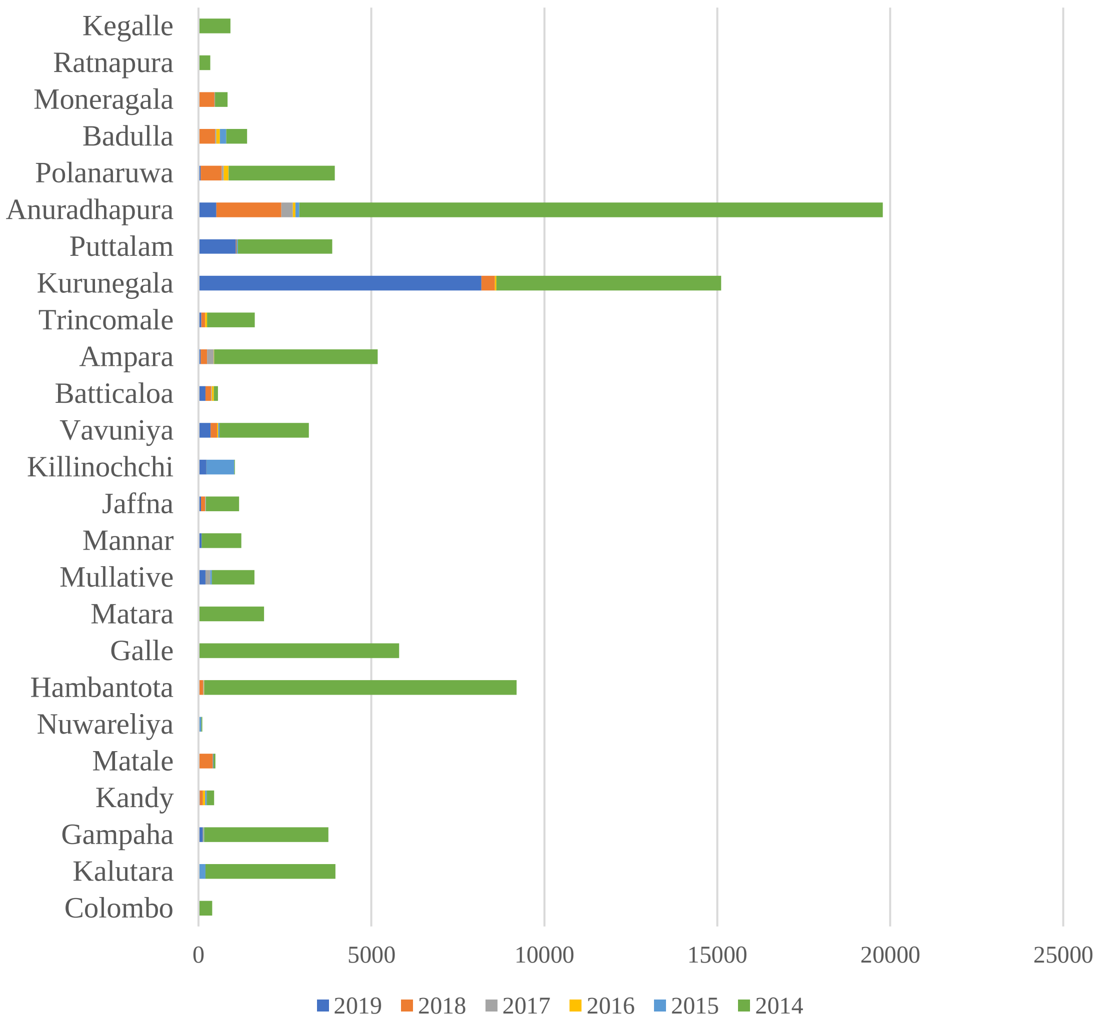


Figure 2.14 District-wise cumulative FMD cases from year 2014 to 2019
Source: AR, DAPH

B) Haemorragic septicaemia (HS)

Haemorragic septicaemia is fatal and causing sudden death among cattle and buffalo resulting high morbidity and mortality. HS was first diagnosed in 1955 in Sri Lanka. The outbreaks were recorded in large herd mainly in dry zone and wet-intermediate zone. In 2019 the HS was confirmed in eastern and north central province caused 115 deaths. It has successfully controlled by locally produced alum precipitated and oil adjuvant vaccine. The last outbreak was found in Kalutara district in 2004, and thereafter typical clinical HS cases have not been identified up to 2015 (Figure 2.15). The HS surveillance was strengthened from the declaration of "provisional freedom" in 2012 (DAPH, 2014).

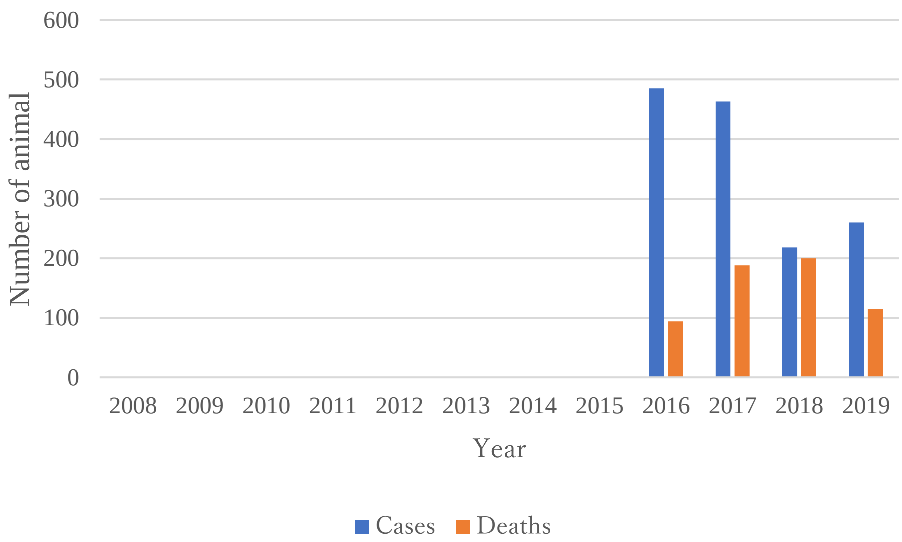


Figure 2.15 HS outbreak
Source: AR, DAPH

C) Black quarter (BQ)

Black quarter is caused by clostridium species, cause high mortality among cattle and buffalo. BQ cases were reported annually in dry zones (Figure 2.16). The clinical cases were detected in Ampara district in 2018 and 2019 (DAPH, 2019).

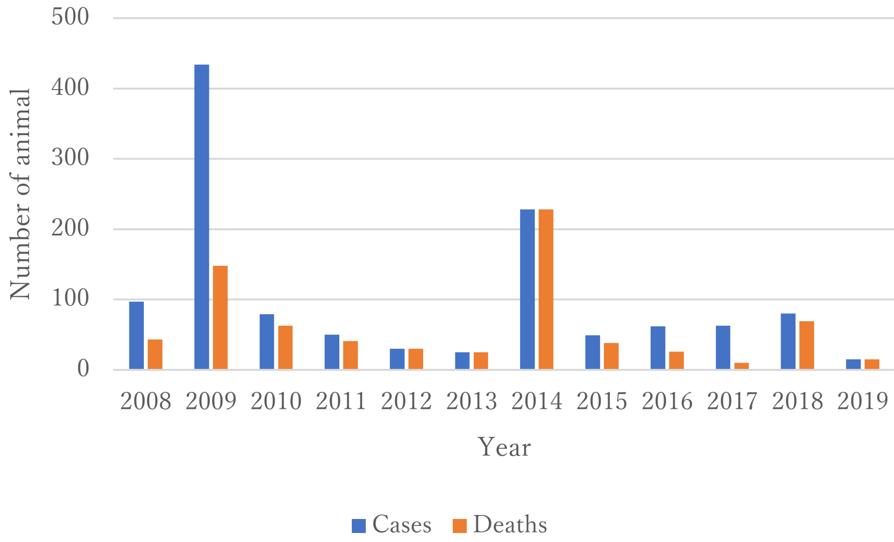


Figure 2.16 BQ outbreak
Source: AR, DAPH

D) Bovine brucellosis

Bovine brucellosis is endemic since 1956. First diagnosed in Polanaruwa state farm with prevalence of 22.5% (Kumaraswamy, 1971). This is an economically important disease of cattle and buffalo which affect reproduction. It is zoonotic disease, endemic certain areas of eastern and north central province in Sri Lanka. Abortions were recorded due to this disease. S-19 brucella vaccine was developed by the VRI to give protection to animal. High incidence of disease was reported in Vavuniya district and 6,931 animals were vaccinated by Veterinary Investigation Centres (VIC) in 2019 (DAPH, 2019). All female animals and exposed animals have to vaccinate in infected farms and calves below six months and pregnant animals should avoid from brucella vaccine. The same farm continues the annual vaccination for four years.

E) Bovine tuberculosis (BTB)

Bovine tuberculosis is caused by *mycobacterium bovis* and it is zoonotic nature. VIC involve for the screening for BTB. 153 animals were reported positive out of 1645 animals screened by test of tuberculin purified protein derivatives in 2019 (DAPH, 2019). The control program on BTB has been implemented at national level. BTB has been reported and confirm in cattle population government and private farms since 2012. Around 9000 new human tuberculosis cases were recorded each year in Sri Lanka. (DAPH, 2016).

Another main zoonotic disease is leptospirosis caused by spirochetes belongs to different species of genus Leptospira (EB, 2013). Bovine leptospirosis is an emerging infectious disease and public health issues (Gamage et al., 2012).

Bovine babesiosis or tick fever cause severe impact to European cattle breed and cause mortality. Crossbred cattle show resistance to this disease. Most of the cases were reported in wet zones and 4,771 cases were recorded in 2019 (DAPH, 2019). Tick control is vital for prevention of this disease. Tick fever vaccine has been produced to immunize the calves in up country area for large dairy herd (EB, 2012).

Mastitis is the most prevalence and costly disease in dairy herd in world-wide (Miller et al., 1993). and also, one of the major serious disease in Sri Lanka too. DAPH produce intra mammary infusions for the treatment of mastitis and given to farmers with free of charge in veterinary range level. For the early detection sub-clinical mastitis California Mastitis Test (CMT) is performing and also issuing teat dip solution for dairy farmers in order to improve the hygienic farm management.

The last clinical case of Rinderpest reported in 1994 and thereafter the provisional declaration of freedom from Rinderpest was announced in 1999. The global declaration of freedom of Rinderpest was aimed and achieved in 2010 by surveillance for accreditation. After submission of dossier to the OIE, Sri Lanka declared as "Rinderpest free" country in December 2010 (DAPH, 2010).

2.3.2 Animal disease control and veterinary services

The veterinary services for the livestock sector are provided through DAPH. The diseases are diagnosed, treated and vaccination campaigns implemented. In addition, provision of technical expert service, the DAPH implements a range of statutes as well, pertaining to the livestock sector. The division of Animal Health is responsible for ensuring required animal health status for development of the livestock industry in Sri Lanka. Animal health division has the national unit located at headquarters of DAPH. Policy initiatives were taken by the government in 2006 to expand veterinary Investigation services in the country, to cater to the growing demand from the livestock industry. Accordingly, a phased-out program was planned and implemented to establish a VIC for each district in the country.

VIC's are operate under the animal health division of the DAPH and responsible of providing laboratory back up services for divisional veterinary offices in respective district. These centres are also responsible for disease surveillance activities, laboratory confirmation and disease investigation services.

The functions of animal health division on vaccination are design, support, monitor and evaluate mass-scale preventive vaccination program in the country. Establishment and maintenance of district based veterinary investigation network. Maintenance of vaccine bank and veterinary-store to ensure the quality vaccine. The main activities are maintenance of vaccine bank, island wide distribution of vaccines and monitoring of livestock vaccination program. Preventive vaccination programs have been carried out against major livestock diseases such as FMD, BQ and HS.

All the vaccines were maintained at the vaccine bank and supplied to the provinces as per the vaccine requirement and vaccination schedule. These were transported in refrigerated vaccine transport truck and distributed at district level and in some occasions to the veterinary ranges directly.

The target FMD vaccination was 970,160 doses and achieved 852,635 cattle and buffalo immunized in 2019 (Figure 2.17). In figure 2.18 shows pattern of issued FMD vaccine in terms of achievement from year 2008 to 2019. Cattle and buffalo vaccinated in eastern province was 226,476 out of estimated total animal population (cattle and buffalo) was 410,835 (55.1%) in year 2019. This amount of achievement indicated as highest in eastern province than other provinces in 2019 (Figure 2.19).

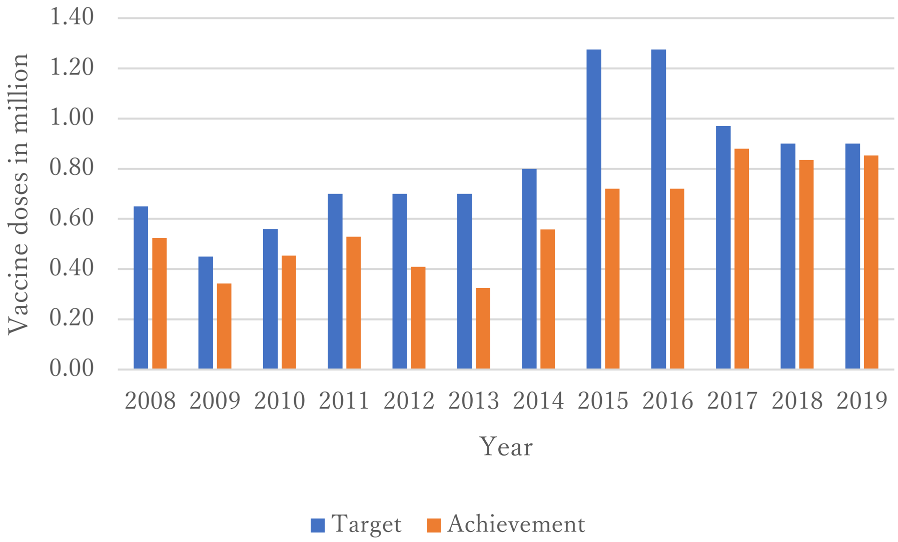


Figure 2.17 FMD vaccination target and achievement in Sri Lanka

Source: AR, DAPH

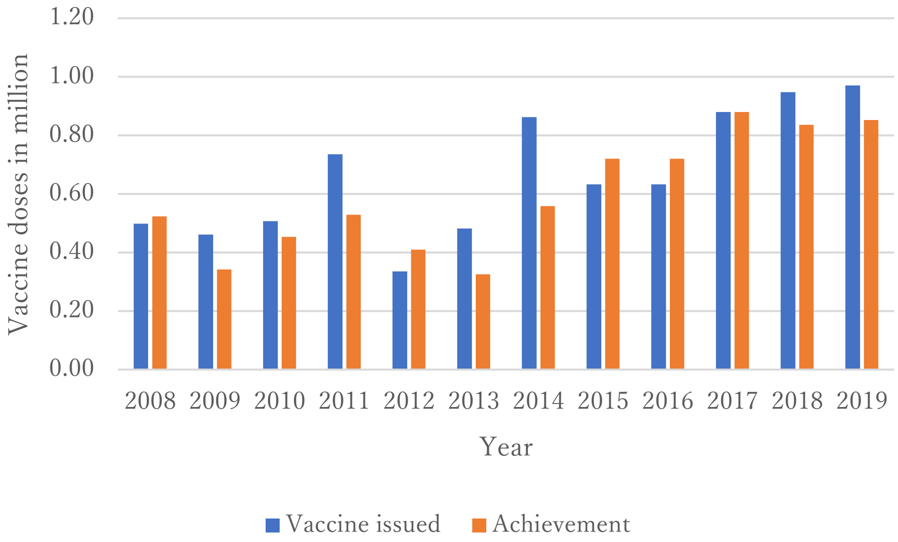


Figure 2.18 Issued FMD vaccine and achievement

Source: AR, DAPH

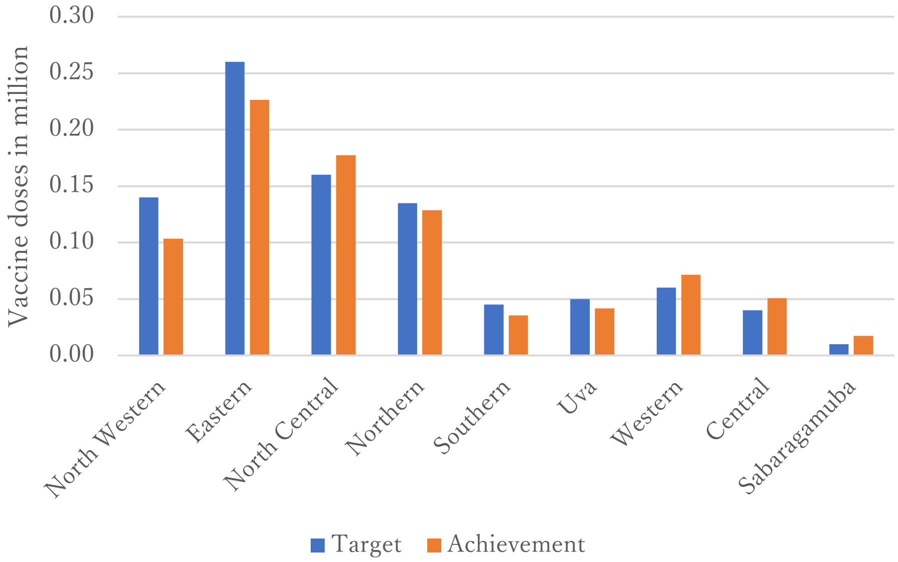


Figure 2.19 Province-wise FMD vaccination program in 2019
Source: DAPH, 2019

2.3.3 Animal health legislation

The animal disease act and its regulations adopted and covered general animal disease control activities. Notifiable diseases listed in schedule one of the acts were reportable to DG, DAPH. All animal diseases listed under the act had to be directly reported to the DAPH by government veterinarians monthly. When case of FMD, HS and BQ, it has to be immediately reported to DAPH, DG. Weekly reports were to be made thereafter until an outbreak was over and for a further five weeks or until no further cases were detected. These reports were based on passive surveillance using clinical diagnosis not supported by laboratory findings (Dissanayake et al., 2012). Veterinary regulatory activities are implemented by statutory provisions of Animal Act No. 29 of 1958, Animal disease Act No. 59 of 1992, Animal Feed Act No. 15 of 1986 and regulation. The Animal Diseases Act include general provisions for border inspection and import requirements, declaring and maintaining zones of infection for disease control, authority for animal emergencies, quarantine and animal movement restriction and culling and carcass disposal.

2.3.4 Veterinary extension system

Animal health priorities have focused on rural development. Presence of animal disease in livestock is an impediment towards sustainable livestock production. There is essential to give attention towards livestock sector in order to develop extension system which can reach livestock farmers and their problems. Veterinary extension is an important tool in achieving the changes in animal production, which has been created, adopted and developed over the centuries for the dissemination (Khoury, 2011). Human resource development division of DAPH is responsible for the national level program. Animal husbandry training centre is responsible for divisional level farmer training in different field. Livestock exhibition, information to farmers through mass media, and booklets, leaflets also kind of extension services to livestock farmers.

2.4 Conclusion

Animal health management is to ensure the development and productivity of livestock by preventing disease incidence, controlling and eradicating prevailing diseases. Loss in production due to infectious diseases such as FMD, HS, BQ and brucellosis. FMD is the major challenging disease with continuous outbreak and cause production loss. DAPH is main institution for the prevention and control program.

Social factors, farm factors, knowledge and attitudes of farmers are important aspect for better contribution for the disease control. Farmers' embedded behavior also consider for control of disease. Awareness program should be extended for the farmers on hygiene management, better farm practices, and importance of vaccinate the animal. There is a knowledge gap in livestock farmers, therefore the training and extension services play an important role to improve the farmers' knowledge on FMD control. As an attempt to provide effective service to the farmers, enhancing the veterinary service through expanding the present services for the national FMD strategy control.

CHAPTER 3

Farmers' knowledge, attitudes and practices regarding foot and mouth disease

3.1 Introduction

The knowledge, attitudes and practices (KAP) is use to investigate human behavior aspect. KAP study is representative to collect information on what is known, believed and done in relation to a specific topic (WHO, 2008). The KAP survey was developed in 1950 and this research originally designed for family planning. KAP surveys were popular during fifties and sixties and different types of KP studies were carried out in several countries (Bulmer and Warwick, 1993). According to Vandamme (2009), KAP studies describe three different purposes which are describe the KAP concept, use for problem identification and intervention planning and use as an evaluation tool to evaluate the effectiveness of certain intervention or programs. There are various qualitative studies on the KAP survey have been carried out in animal health globally.

Knowledge plays a vital role is attributed to wide variety of properties and qualities. Different types of knowledge encountered: generic and domain specific knowledge, concrete and abstract knowledge, formal and informal knowledge, declarative and procedural knowledge, elaborated and compiled knowledge, unstructured and structured knowledge, tacit or inert knowledge, strategic knowledge, knowledge acquisition, situated knowledge and meta knowledge (De Jong and Ferguson, 1996). Attitude formation is a result of learning, modeling others, and our direct experiences with people and situations. Attitudes influence our decisions, behavior and impact selectively remember. Attitudes come in different strengths, and mostly from experience and can be measured and changed (Allport, 1935). Knowledge is the important strategic resources of 21st century and knowledge sharing are influenced by multi-level factors which provides a theoretical basis for enterprises to enhance knowledge dissemination. Knowledge is the organization's major strategic resource that can provide organizations with a sustainable benefit and knowledge management depends on knowledge sharing. Organizational level, team level and individual level factors are influencing the knowledge sharing (Zheng, 2017).

Knowledge, attitudes, and practices (KAP) in relation to FMD is important for an effective livestock disease control program. Understanding farmers' KAP and their preparedness to adhere to these measures are important factors for determining effective control strategies. (Jemberu et al., 2015). Knowledge is the basic farmers' characteristics which can develop their perception, attitudes, motivation and practices. Sufficient knowledge helps farmers provide choice of management system on farm practices. Knowledge is gained by process of experiencing new practices and by learning the concept of good agriculture practice from expert their partners in field. Sharing the knowledge through training in livestock management extension called dissemination. KAP study on farmers regarding organic farming in Bangladesh revealed training on organic farming positively with knowledge, experience in organic farming positively influence towards attitudes change and cosmopolitanism showed good practices to organic farming (Shijan and Matiul, 2020). The KAP survey is attributable to the characters of easy design, quantifiable data, ease of interpretation and concise interpretation of results, generalizability of small sample results to whole population, cross-cultural comparability, speed of implementation and ease with which one can train numerators (Launiala, 2009). To identify the knowledge gaps, cultural beliefs, behavioral patterns impediment to control of infectious diseases is KAP frame work (Launiala, 2009). Better understanding farmers' knowledge and learning processes is a main goal towards sustainable agriculture practices. In social science research which seeks to uncover the nature and complexities of farmers' knowledge both relating to how they understand their farm environment as well as potential knowledge conflicts that may arise when farmers come into contact with others, conservation focused, environmental knowledge (Reed et al., 2010; Riley, 2008). Regarding the zoonotic diseases, livestock farmers are particularly exposed to risks. The lack of basic knowledge level, biosecurity precaution, and personal hygiene of livestock farmers can play a part in the infection and spread of zoonotic diseases (Weese et al., 2002; Cedial et al., 2012). Concept of activities occurring in the interface of human, animal, and environment, livestock farmers who have knowledge about zoonotic diseases can act willingly in taking precaution and attending disease control program. The KAP study about zoonotic diseases in Turkey showed that the increase in education status, size of the enterprise, and monthly income of cattle farmers was related to increase in KAP regarding zoonotic diseases (Özlü et al., 2020). Wildlife, livestock and humans are the main contribution for the wide spread of important infectious diseases due to considering the current knowledge gap (Wiethoelter et al., 2015). Small holder farmers have poor knowledge and their contribution for the control of animal disease program is important (Grace et al., 2008).

Organization of beliefs, feelings and behavioral tendencies towards objects, events, individuals or groups define as attitudes (Hogg and Vaughan, 2005). The function of attitudes is to provide the information, and it can be positive, negative or uncertain towards an action (Mankad, 2016). Study on attitudes and perception for the farm biosecurity has mainly conducted in animal husbandry for the control of FMD and other diseases found in animal production (Buetre et al., 2013). In UK, the farmers mostly concentrate on biosecurity of the farm as good attitudes to prevent the disease is cost-effective and time efficient than treating diseased animal (Brennan and Christley, 2013).

Farmers' behavior is strongly affected by their knowledge and attitudes (Dernburg et al., 2007). The findings of KAP studies on brucellosis zoonosis could also be applied to control FMD in dairy farming. Risky farming behavior due to poor KAP of dairy farmers has been identified as a contributing factor for the proliferation of brucellosis (Hegazy et al., 2016; Musallam et al., 2015). A Cambodian study of FMD showed that the mean knowledge score of livestock farmers was as low as 28.4%, while basic biosecurity practices were also poor (Young et al., 2017). As part of the FMD control policy, prevention programs are being implemented each year through government veterinary offices in Sri Lanka. However, there is a widespread prevalence of FMD, affecting the animal clinically or sub-clinically, resulting in economic losses in the national dairy sector. The better livelihood enhances the knowledge, higher knowledge promotes good attitudes, and good attitudes initiate good practices.

Therefore, we explored the gaps in livestock owners' KAP to address the socio-economic consequences of FMD in Sri Lanka. This information is essential for future control programs and interventions for policy implications.

The objectives of this chapter,

1) To describe and evaluate the baseline farmer KAP among dairy farmers with regard to FMD control
2) To elucidate the potential social and farm factors influencing KAP

3.2 Materials and methods

3.2.1 Study area and data collection

This study focuses on the district of Ampara in the dry zone owing to the diverse socio-cultural backgrounds with different livestock management systems, in addition to the high incidence of FMD (Wickramasuriya et al. 1983). The study included the Kalmunai (KAL), Navithanveli (NAV), and Sammanthurai (SAM) ranges. The ethnicity of these ranges were mainly Muslims and Tamils who engaged in livestock farming, and the main language spoken was Tamil. These areas have a high density of people and cattle living together and are dominated by small-scale dairy farmers. The study subjects included both small and large-scale dairy farmers.

The farmers were randomly selected from the three ranges in equal proportions of 60 samples each, comprising 180 respondents overall. This study was conducted among cattle farmers during September and October 2019. The pre-questionnaire survey was conducted with farmers in three ranges. The questions were either dichotomous or open. Data were collected from the farmers through a questionnaire in their own language, which included information such as demographic characteristics, knowledge, attitude, and practices related to FMD. All farmers were interviewed at their home or farm. Prior to administering the questionnaire, the outline was described for the purpose. A brief clarification of research was provided and oral consent to collect data was obtained. The survey questions were included the farmers' characteristics, FMD knowledge, attitudes and management practices. The farmers detail includes the general information of family, age of head farmer, gender, educational background, main job and the decision maker of farm. Additionally, income of dairy farm, other livestock, crop and off farm information also included. The farm factors included the registration of farm, number of livestock and type of farm management practice. Further, farmer training and experience on animal husbandry, assistance for animal health service in veterinary office when animals are sick, mode of communication with veterinary authority were recorded. To find out knowledge of farmer the eight questions of clinical signs of FMD, transmission of disease and vaccination were prepared. Also included the farmers attitude and hygiene management practice questions were considered.

3.2.2 Data analysis

Data obtained from the questionnaires were entered into an excel worksheet. First, to elucidate the condition of dairy farming in the district, the main social and farm factors were summarized. Descriptive statistics were generated for selected variables. A t-test and chi-squared test were conducted to compare these factors between the two ethnicities.

Second, to analyze the FMD score, questions related to KAP were considered. There were eight questions to gauge knowledge of FMD, with "true," "false," and "do not know" options as answers. A correct answer was given one mark, while incorrect and do not know answers were considered as zero. Questions on knowledge were used to determine respondent's general knowledge regarding the disease, its clinical signs, mode of transmission and vaccination. Four attitude questions were considered to estimate the score of attitudes. Five management practice questions were included to estimate the score of practices, for which yes/no answers were provided as responses. For attitudes and practices questions a correct answer was given one point, while incorrect answer was considered as zero point.

All individual answers to knowledge, attitudes and practices questions were computed to obtain total mean score of KAP separately. To calculate total KAP score of a farmer obtained by dividing sum of total points of KAP by the total number of respondents. Questions on attitudes and practices were used to assess farmer's perception on prevention and control measures. Overall, there were 17 questions related to KAP for FMD, if a farmer answered all questions correctly 17 scores were awarded in which 8 points (47%) attributed to knowledge section, 4 points (24%) to attitudes and 5 points (29%) to practices.

The t-test was used to compare the social factors, farm factors, and KAP-related questions between two ethnicities. Third, a linear regression model was used to investigate the association between total KAP and social and farm factors. The data collected from the study were analyzed using the statistical software STATA 16.

Linear regression model was considered between the dependent variable and independent variable. When there is only one independent variable in the linear regression model term as a simple linear regression model. When there are more than one independent variables. The linear model called as multiple linear regression model.

The equation for linear regression of total KAP describe as

$$Total\ KAP = \alpha_0 + \beta . social\ factors + \gamma . farm\ factors + \varepsilon$$

$Note: \alpha_0 - constant,\quad \beta, \gamma - coeffient\ of\ social\ and\ farm\ factors,$

$\varepsilon - error\ term$

Social factors include age of head of farmer, gender, ethnicity, range (KAL and NAV), education, income and farmer training. Farm factors include number of animals, farming experience and farm management-extensive.

3.3 Results

3.3.1 Social and farm factors

The average age of the farmers was 47, and 32.2% of farmers were interviewed between 41 to 50 age group (Figure 3.1). Table 3.1 demonstrates all three ranges. Overall, male farmers accounted for 88.3% of the sample size, and females approximately 10–15%. The ethnicity of farmers in KAL and SAM was mainly Muslims, while Tamils (66.7%) accounted in NAV and 57.8% of the respondents had obtained formal education. The main source of income was agriculture, private jobs, and livestock. On average, 25.6% of livestock farmers engaged in private jobs, such as fishing, business, and labor work with KAL range (41.7%). With regard to farm factors, the average number of animals was higher (25.0 per farm) in the SAM range, while it was 11.7 and 16.7 in KAL and NAV, respectively. Farmers followed an extensive farming system in SAM (55.0%), while it was 1.7% and 5.0% in KAL and NAV, respectively. Farmers' involvement in the semi-intensive system was very high. Farming experience was also high in the SAM range (83.3%).

Farming experience and the educational level of farmers were not significantly different between Tamil and Muslim respondents, but participation in the training program was higher among Tamils (33.8%) and 17.8% among Muslims, at a 5% significance level. The proportion of farmers engaged in other businesses was 1% significance among Muslims. The results showed that, on average, a few farmers attended the training program (23.9%) conducted by veterinary offices. Most of the farmers had more than five years of farming experience (73.3%).

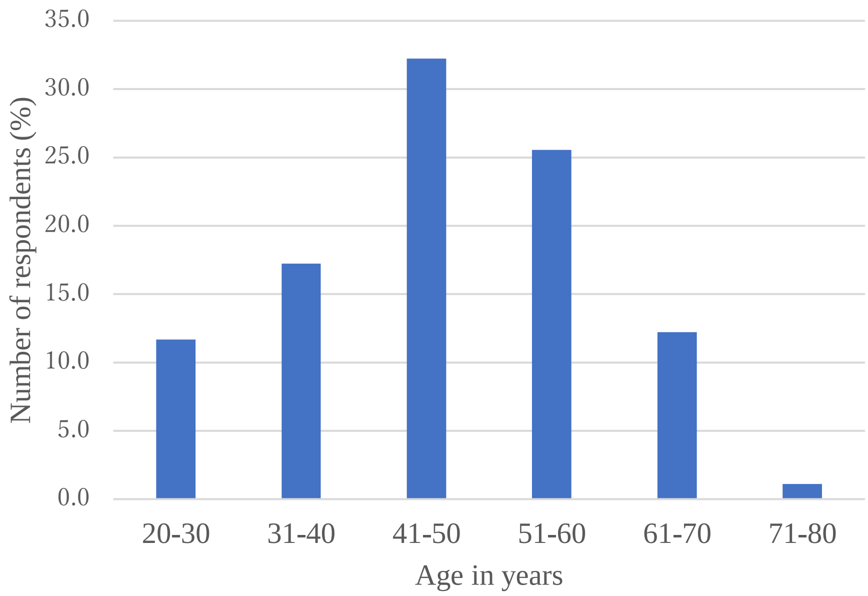


Figure 3.1 Age distribution among participants
Source: Field survey

Table 3.1 Summary and descriptive statistics of the main social and farm characteristics between two ethnicities

Variable	Category	Overall N=180	T N=68	M N=112	
Social factors					
Age	Continuous data	46.9 (12.10)	45.0	48.0	
Gender	1: Male; 0: Female	88.3 (0.32)	83.8	91.1	
Ethnicity	1: Muslim; 0: Tamil	62.2 (0.48)	0	100.0	***
Range	1: NAV; 0: KAL, SAM	66.6 (0.47)	91.2	51.8	***
Education	1: Formal; 0: other	57.8 (0.49)	52.9	60.7	
Income source	1: Private; 0: other	25.6 (0.44)	13.2	33.0	***
Farmer training	1: Joined; 0: Did not join	23.9 (0.42)	33.8	17.8	**
Farm factors					
Number of animals	Continuous data	18.8 (28.65)	14.3	21.5	
Farming experience	1: > 5 year; 0: < 5 years	73.3 (0.44)	73.5	73.2	
Farm management	1: Extensive; 0: other	20.6 (0.40)	10.3	26.8	***

Note 1: Figures are presented as mean and standard deviations in parenthesis.

Note 2: The difference between T and M are statistically significance at the 5% ** and 1% *** level respectively.

Note 3: Pearson's chi-squared test and t-test were applied for binary and continuous variables respectively.

Note 4: T and M are abbreviation of Tamil and Muslim respectively.

Source: Field survey

3.3.2 Knowledge of FMD

Figure 3.2 shows the farmers correctly answered questions regarding FMD symptoms, such as reduced milk production (68.3%), animal lameness (82.2%), salivation (80.6%), and blisters in the mouth (62.2%). However, only 47.8% of the farmers believed that FMD did not transmit from animals to humans, while 26.1% correctly mentioned that the disease was transmitted through air and that the age of the first vaccination is not at one year This revealed the poor knowledge of the mode of disease transmission and the age of vaccination. Farmers knew FMD symptoms related questions were higher knowledge than disease transmission and vaccination related questions. More than 50% of farmers had knowledge about clinical signs of FMD. Table 3.2 describes the means of KAP regarding FMD between two ethnicities and overall. The overall FMD knowledge score was 4.36. In Figure 3.3 around 11.1% of farmers had zero score in FMD knowledge and 23.3% of farmers had knowledge score 4. There were only 2.2% of farmers who knew all the FMD knowledge questions in the study and complete knowledge with score 8.

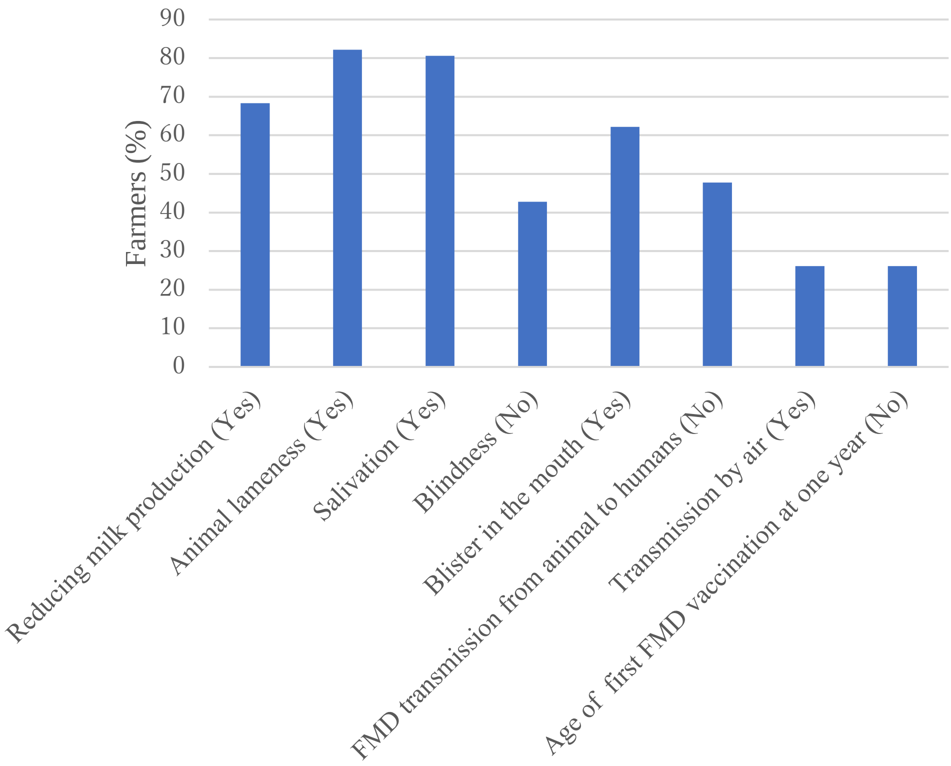


Figure 3.2 Farmers percentage correctly answering FMD knowledge questions in overall

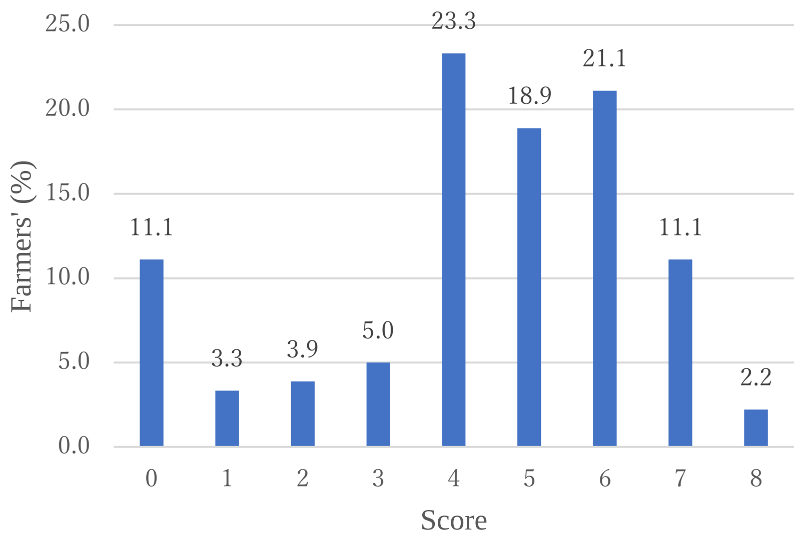


Figure 3.3 Farmers' knowledge FMD score

3.3.3 Attitudes and practices

Among the respondents, 83.9% reported FMD as one of the main livestock diseases to the veterinary office. The proportion of farmers who did not sell sick animals and participated in the FMD vaccination drive was 88.9% and 81.1%, respectively (Figure 3.4). Regarding the usefulness of vaccination cards (can be used for the FMD vaccination detail of a particular farm) was significant among Tamils. Tamils also paid significant attention to details such as the use of detergents, not sending sick animals for grazing, and isolating diseased animals at 1% (Table 3.2).

Around 60% of farmers had the attitudes score was 4. There was only one farmer had poor attitudes score 1 (Figure 3.5). Among the disease preventive practices use of foot-wear and detergent was 55.0% and 62.2% respectively in overall. 42.2% of farmers were not send the sick animal for feeding to outside from the farm in the sense of animal movement (Figure 3.6). 24.4% of farmers had practice score was 2, on the other hand around 9% farmers performed all relevant practices mentioned in this study (Figure 3.7).

The overall attitude and practice scores were 3.49 and 2.46, respectively. Management practices were significant among Tamils. Overall, the KAP score was 10.32, which was significant among the two ethnicities (Table 3.2).

Table 3.2 Knowledge, attitudes and practices comparison between two ethnicities

Variable	Overall	T	M	
Knowledge				
Reducing milk production (Yes)	0.683	0.529	0.777	***
Animal lameness (Yes)	0.822	0.823	0.821	
Salivation (Yes)	0.806	0.853	0.778	
Blindness (No)	0.428	0.397	0.446	
Blister in the mouth (Yes)	0.622	0.720	0.562	**
FMD transmitting from animal to human (No)	0.478	0.456	0.491	
Transmit by air (Yes)	0.261	0.309	0.232	
Age of first FMD vaccination at one year (No)	0.261	0.294	0.241	
Knowledge total score	4.36	4.38	4.35	
Attitudes				
Report FMD (Yes)	0.839	0.794	0.866	
Not sale of sick animals (Yes)	0.889	0.853	0.911	
Participate FMD vaccination (Yes)	0.811	0.838	0.795	
Vaccination card useful (Yes)	0.955	1.000	0.929	**
Attitudes total score	3.49	3.48	3.50	

Practices				
Use foot-wear (Yes)	0.550	0.618	0.509	
Use detergents (Yes)	0.622	0.853	0.482	***
Sick animals not send for grazing (Yes)	0.422	0.574	0.330	***
Separate diseased animals (Yes)	0.506	0.706	0.384	***
Change clothes (Yes)	0.361	0.294	0.402	
Practice total score	2.46	3.04	2.11	***
Total KAP score	10.32	10.91	9.95	**

Note 1: In parentheses Yes- correct answer and No- incorrect answer. Figures are presented in mean of each category.

Note 2: The difference between T and M are statistically significance at the 5% ** and 1% ***level respectively.

Note 3: Pearson's chi-squared test and t-test were applied for binary and continuous variables respectively.

Source: Field survey data (N=180)

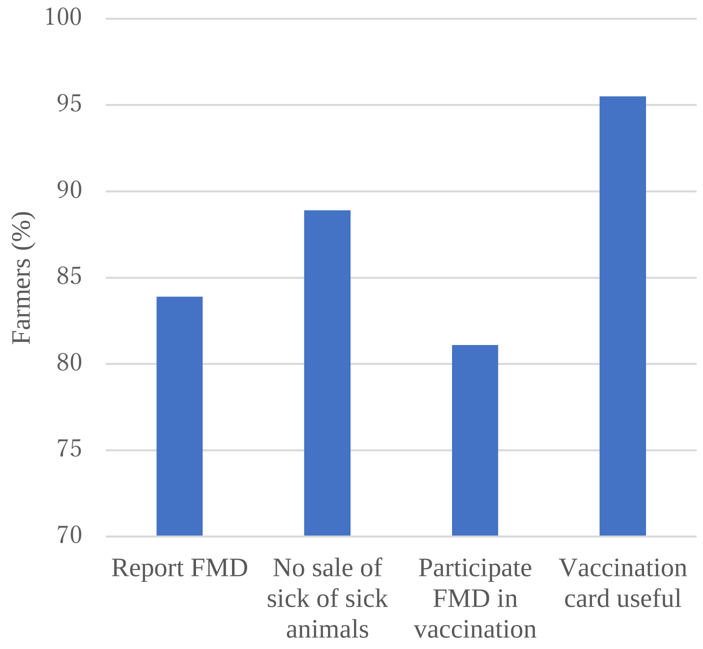


Figure 3.4 Farmers percentage correctly answering attitudes questions

Note: When ask the question about vaccination card is useful for FMD vaccination detail more than 95% of farmers answered "yes"

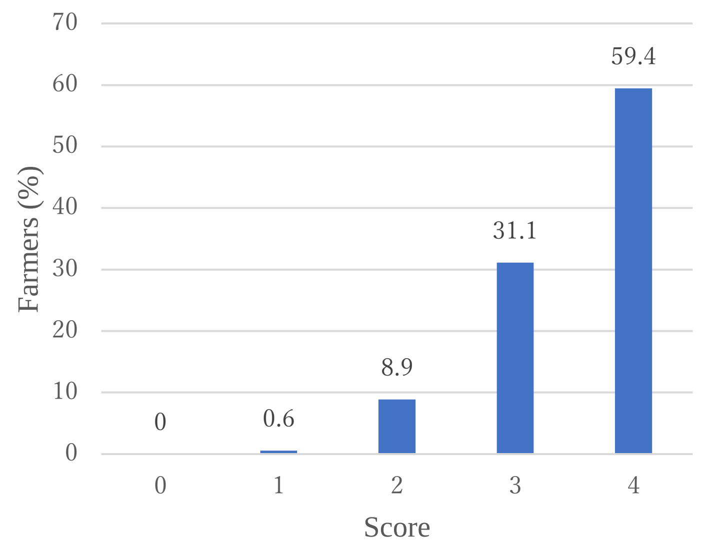


Figure 3.5 Farmers' overall attitudes score

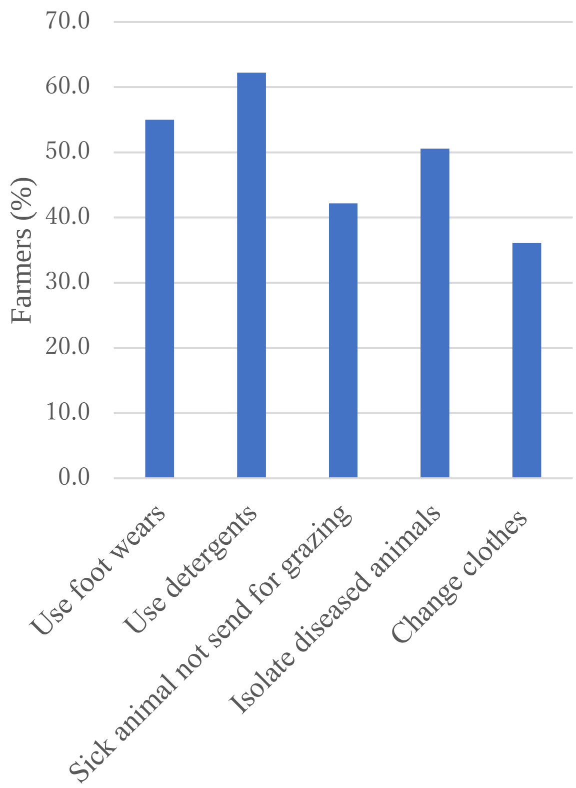


Figure 3.6 Farmers percentage undertaking preventive practices

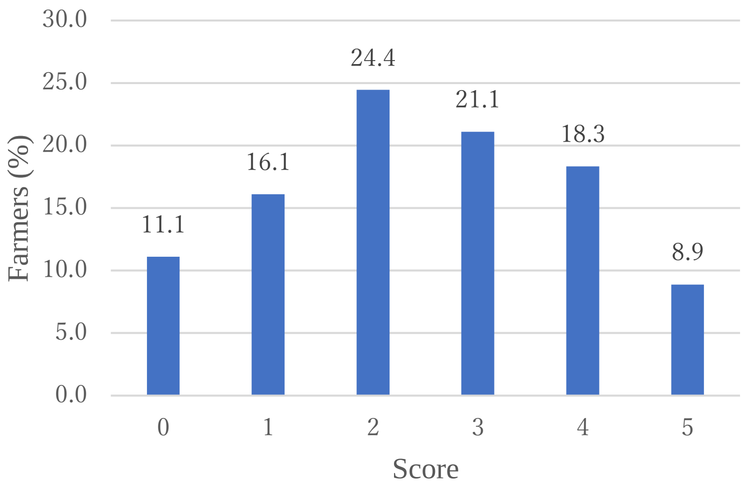


Figure 3.7 Farmers' overall practice score

3.3.4 Factors influencing overall KAP scores

In Table 3.3, the KAP based on social factors were the age of the farmer, gender, ethnicity, range, education, income source, and participation in the farmers' training program. We noticed that farmers having education positively influenced KAP on FMD ($p < 0.05$). However, ethnicity and the income source of farmers did not influence the gain of the KAP. The outcome of attending the training program in livestock management was also significantly important to improve KAP on FMD ($p < 0.05$). Among the ranges, NAV was significantly influenced by the total KAP FMD score.[1)]

The knowledge itself (Table A) of male farmers and training program attendance were significant, and in farm factors, the higher number of animals and farming experience influenced the knowledge score for FMD ($p < 0.05$). Table B revealed that only ethnicity ($p < 0.1$) and range NAV were positively significant for farmers attitudes, however for the practice score farmers' education ($p < 0.01$) and farming experience ($p < 0.05$) were significant. Among the study areas, the NAV range was more significant ($p < 0.01$) than the other two ranges for practice score.

Regarding farm factors, the overall animal and farm management system was not influenced by KAP. Farmers who engaged in cattle rearing for more than five years significantly influenced KAP scores ($P < 0.05$).

Table 3.3 Factors influencing on KAP FMD score (Regression analysis)

Variable	Coefficient	t – value	P > [t]
Social factors			
Age	0.024 (0.021)	1.17	0.245
Gender	1.067 (0.675)	1.58	0.116
Ethnicity	0.355 (0.525)	-0.68	0.500
Range - KAL	-0.142 (0.699)	-0.20	0.839
Range - NAV	1.413 (0.706)	2.00	0.047**
Education	1.173 (0.506)	2.32	0.022**
Income source	-0.191 (0.529)	-0.36	0.719
Farmer training	1.253 (0.516)	2.43	0.016**
Farm factors			
Number of animals	0.011 (0.008)	1.27	0.250
Farming experience	1.183 (0.520)	2.27	0.024**
Farm management-Extensive	-0.607 (0.735)	-0.83	0.410
constant	6.146 (1.275)	4.82	0.000***

Note: *** and ** denoted statistical significance at the 1% and 5% level. Number of observations = 180, standard errors in parentheses, adj R-squared = 0.156, prob. > F = 0.000

Source: Field survey data

3.4 Discussion

On average, the majority of farmers were aware of clinical symptoms such as lameness and salivation to identify FMD from various other cattle diseases, but had poor knowledge of the mode of transmission and the age of vaccination, which are important factors in controlling FMD in endemic areas. The practices related to FMD were exhibited by the farmers at a relatively lower level (Table 3.2). There are several veterinary ranges in the district of Ampara, including in KAL, NAV, and SAM. The mean of the extensive farming system was 20.6% in the study area. In KAL and NAV, the farmers were mainly involved in semi-intensive farming. In NAV, 15% of farmer families were headed by women, and their main source of income was livestock. The farming experience is also clearly described for the KAP score among farmers. Cattle owners engaged in animal rearing were continually motivated for best practices and attitudes. The study revealed a moderate level of knowledge and poor practices towards FMD. Understanding KAP has been defined as an important pillar regarding the feasibility and acceptability of potential measures that have been instituted. Farmer-extensionist communication positivity improves the knowledge of dairy farming (Rezvanfar, 2007). To improve farmers' KAP of FMD, livestock educational training programs are an important tool to control disease outbreak in the study area. Presently, farmers' training mainly focuses on cattle, goat and poultry management on feeding, diseases, and milk value addition. To improve farmers' knowledge of FMD, it is imperative to promote good attitudes and management practices. Training programs should be organized at a convenient time and place for better participation of farmers, since they are also involved in occupations other than dairy farming. The effect of farmers' behavior in different socio-economic features impediments for adoption of new technology for the control of FMD. The KAP study suggests that improvement in continuous persistent training program is considered for control of FMD and regular vaccination program would motivate farmers' adoption to change embedded behavior. To effectively enhance the KAP of farmers toward FMD control, it is important to categorize the farmers according to their educational level and farming experience (how many years have they been involved in livestock rearing) for successful farmer educational program, and identify the subjects that are poor in livestock disease control measures. When organizing farmer educational training programs, some experienced livestock farmers may not participate, because they believe that they know everything with respect to animal disease control and are already following their own methods and beliefs. For effective animal disease control, farmers from all educational backgrounds and experiences should consider participating in the training program. The farmers' ethnicity, location, main job, farming experience and number of animals should be considered to organize successful training program. Farmer to farmer extensions have proved to be practical, cost-effective (Wellard et al., 2013). And this community extensions are effective in African countries (Wolmer and Scoones, 2005). These social and farm factors are not accounted in the present training. Therefore, these factors are important for a viable training program in the future as a policy implication.

The farmers' decision to accept the vaccination will mostly depend on the level of awareness of their knowledge of FMD through capacity building. Therefore, this study vividly highlights the importance of taking into consideration identification, mode of transmission of FMD, vaccination, and hygiene management practices of livestock farms. Sanitary practices are important tools (Barkallah et al., 2017) to prevent the transmission of the disease. There is need to establish strong communication bond between veterinary authorities and the farmers while inspecting the livestock herd in the area. Adopting this activity provides benefits for farmers and livestock industry (Crowe and Oxtoby, 2019). Communication between farmers and veterinarians has been revealed as a necessary tool improve dairy farm management (Jansen et al., 2010; Kristensen and Jakobsen, 2011). Veterinarians working in close contact with farmers and address the health issues of cattle to reduce the economic burden of disease on the farmers. For controlling FMD outbreak, farmers should be aware of the economic outcomes of the disease. Currently, in eastern provinces, a mass vaccination program is being implemented by the DAPH.

This study revealed that for successful FMD control programs, it is important to identify and promote farmers' knowledge, management practices, and good attitudes. For the selection of farmers to extend the program, priority should be given to successful (key farmers), experienced, and interested farmers. In livestock training, since it is not feasible to include all farmers in one group, trained farmers should disseminate the information and technologies to their neighbors for successfully achieving the objectives (Nakano et al., 2018). Therefore, disease control authorities and policymakers should consider disseminating these issues as important tools for the control of FMD in Sri Lanka.

3.5 Conclusion

It is imperative to educate farmers on the impact of FMD and associated control measures, including knowledge on disease identification, transmission mode, vaccination, and best animal husbandry practices, in farmer training awareness programs. KAP scores have been identified to understand the knowledge of farmers and factors that influence the transmission of FMD in the study areas. Therefore, KAP-related issues should be considered as a possible control strategy. Animal health educational extension strategies should be organized properly through informal education to enhance good attitudes and practices related to curtailing the transmission of FMD. Poor knowledge leads to poor attitudes, which leads to unsatisfactory practices that may results in disease outbreak. Farmers with high level of social relationship could be utilized as head farmer in informal knowledge transmission in village level. It is important to focus on the preparation of training modules for disease transmission, identification, and proper vaccination. They should be addressed as part of the FMD control program.

Note:

1. Regression analysis of knowledge, attitudes and practices separately summarized in Table A, B and C. Factors influencing total KAP scores of regression analysis showed in Table 3.3

Table A: Factors influencing on knowledge FMD score (Regression analysis)

Variable	Coefficient	t – value	P > [t]
Social factors			
Age	0.248 (0.015)	1.63	0.106
Gender	0.950 (0.489)	1.94	0.054*
Ethnicity	-0.313 (0.380)	-0.82	0.412
Range - KAL	0.446 (0.506)	0.88	0.380
Range - NAV	-0.297 (0.512)	-0.58	0.563
Education	0.452 (0.367)	1.23	0.219
Income source	0.130 (0.383)	0.34	0.733
Farmer training	0.849 (0.374)	2.27	0.025**
Farm factors			
Number of animals	0.012 (0.006)	1.97	0.050**
Farming experience	0.801 (0.377)	2.12	0.035**
Farm management-Extensive	-0.033 (0.533)	-0.06	0.951
Constant	1.197 (0.924)	1.30	0.197

Note: ** and * denoted statistical significance at the 5% and 10% level. Number of observations = 180, standard errors in parentheses, adj R-squared = 0.147, prob. > F = 0.000

Source: Field survey data

Table B: Factors influencing on attitudes for FMD score (Regression analysis)

Variable	Coefficient	t – value	P > [t]
Social factors			
Age	0.001 (0.005)	0.25	0.803
Gender	-0.302 (0.162)	-1.86	0.064*
Ethnicity	0.215 (0.126)	1.71	0.090*
Range - KAL	-0.069 (0.168)	-0.41	0.683
Range - NAV	0.412 (0.169)	2.43	0.016**
Education	0.089 (0.121)	0.73	0.467
Income source	0.002 (0.127)	0.02	0.988
Farmer training	0.071 (0.124)	0.58	0.565
Farm factors			
Number of animals	0.002 (0.002)	1.15	0.252
Farming experience	-0.085 (0.125)	-0.68	0.498
Farm management-Extensive	-0.154 (0.176)	-0.87	0.384
Constant	3.435 (0.306)	11.23	0.000***

Note: ***, ** and * denoted statistical significance at the 1%, 5% and 10% level. Number of observations = 180, standard errors in parentheses, adj R-squared = 0.079, prob. > F = 0.009

Source: Field survey data

Table C: Factors influencing on practice for FMD score (Regression analysis)

Variable	Coefficient	t – value	P > [t]
Social factors			
Age	-0.001 (0.009)	-0.18	0.858
Gender	0.419 (0.277)	1.15	0.133
Ethnicity	-0.257 (0.215)	-1.19	0.234
Range - KAL	-0.519 (0.287)	-1.18	0.072*
Range - NAV	1.298 (0.290)	4.48	0.000***
Education	0.633 (0.208)	3.05	0.003***
Income source	-0.324 (0.217)	-1.49	0.138
Farmer training	0.332 (0.212)	1.57	0.118
Farm factors			
Number of animals	-0.004 (0.004)	-1.05	0.293
Farming experience	0.468 (0.214)	2.19	0.030**
Farm management-Extensive	-0.421 (0.302)	-1.39	0.165
Constant	1.515 (0.523)	2.89	0.004***

Note: ***, ** and * denoted statistical significance at the 1%, 5% and 10% level. Number of observations = 180, standard errors in parentheses, adj R-squared = 0.418, prob. > F = 0.000

Source: Field survey data

CHAPTER 4

Factors affecting vaccination behavior for foot and mouth disease

4.1 Introduction

FMD is still widespread worldwide. It is prevalent in large parts of Africa, Middle East, and Asia, and countries that are free of FMD remain under the constant threat of incursion (FAO, 2012). While the majority of FMD outbreaks occurs in developing countries where veterinary capacities are minimum, the continuing epidemic of FMD has been described as a failure of the global food security system (Rushton, 2009; Winsdor, 2011). In Southeast Asia, the inclusion of FMD vaccination activities in FMD control and eradication programs is evident in Indonesia and Philippines (Winsdor, et al., 2011). FMD has a long history and was officially reported in 1900 in Sri Lanka (Sturgess, 1900).

The accepted control strategies available for FMD are stamping out, tracing outbreaks, legislation, quarantine, movement control, vaccination, import and export regulations, and zoo sanitary measures (Kodituwakku, 2000). Successful vaccination programs prevent major epidemics of an infectious disease by generating herd immunity. Although FMD vaccination has been carried out every year, low vaccination coverage has caused this disease to rise to epidemic proportions (Fernando, 1969a). A Socio-economic study in the Indian Punjab found that the educational level of farmers could be correlated with the likelihood of FMD outbreaks, and this could be linked to the fact that educated farmers were more likely to seek professional advice and vaccinate their animals regularly (Saini et al., 1992).

The FMD outbreaks would be high due to poor vaccination coverage, thereby resulting in enormous economic losses to livestock (Kodituwakku, 2000). Farmers' knowledge about the disease is very important for an effective control program (Martin et al., 1994). Improving farmers' knowledge to differentiate FMD from other diseases and ensure prompt reporting of any suspicion of FMD as well as prompt restricting of movement of animals is a critical activity for an effective FMD response effort (Goswami and Sagar, 1996).

In the last 10 years, FMD outbreaks were reported in the country, particularly in the dry zone of the eastern province among traditional dairy farming systems in small and large herd populations. Circulation of the FMD virus O type was confirmed in Sri Lanka (Gunasekera and Fernando, 1980). According to the FMD control policy, the FMD mass vaccination program is implemented each year with the coordination of government veterinary offices in nine provinces of Sri Lanka, however the FMD outbreak continues and the animal becomes clinically or sub-clinically affected. FMD vaccination have been carried out in earmarked location in Sri Lanka. The number of target vaccines for FMD was 0.90 million and achieved 0.85 million in year 2019 (DAPH, 2019). The PCP for FMD has been developed to assist and facilitate FMD endemic countries to progressively reduce the impact of disease and extend virus circulation (FAO, 2018a). Cattle owners engage in low FMD vaccinations in different management systems. Farmers' FMD knowledge and vaccination behavior are poorly described. Therefore, we explored the gaps in knowledge of FMD, vaccination behavior, and the bio-security and hygiene management practices that are necessary for control strategy in the socio-economic consequences of FMD in Sri Lanka.

The objectives of this chapter,

1) To clarify the factors influencing participation in FMD vaccination and vaccination coverage

2) To enhance farmers' motivation towards vaccination behavior in the vaccination program is sufficient to control and eradicate FMD

This information is important for policymakers, livestock stakeholders, and small and large-scale traditional farmers, where vaccination and management interventions are expected to be delivered by veterinary ranges providing effective and sustainable FMD control in Sri Lanka.

4.2 Materials and methods

4.2.1 Study area

Sri Lanka follows a diverse socio-cultural tradition. There are different farming management practices, such as intensive and semi-intensive, and other extensively managed large herds, depending on the agro-climatic regions in the country (Kothalawala, 2011). Especially, the eastern province was selected as the area of study because of the high foot and mouth disease outbreak reported in the past (DAPH, 2014). The dry zone covers two third of the land area and around 75% of the total cattle and buffalo population (1.4 million) of the country. The study area of the eastern province consists of approximately one fifth of cattle and buffalo population (DCS, 2018). There are two established livestock management systems in the dry zone, namely the traditional management system (extensive system) in the villages and the semi-intensive or intensive system. Livestock is the primary or most secondary income generation source for the majority (91.4%) of farmers in the traditional system and 51.5% in irrigated settlements (Abeygunawardena et al., 1997).

The district of Ampara is in the southeast region of Sri Lanka and belongs to the eastern province. The government veterinary range is the smallest functional unit of the veterinary delivery system and consists of the number of villages.

Out of twenty ranges, sixteen veterinary ranges of Ampara district affected by FMD in the year 2014 and reported 4,727 cases and 105 deaths (DAPH, 2014). Kalmunai (KAL), Navithanveli (NAV), and Sammanthurai (SAM) ranges were devastated by FMD, therefore, these three areas were considered for the study. The ethnicity of these ranges was mainly Muslims and Tamils who engaged in livestock farming and their main language was Tamil. The total number of registered livestock farms, including cattle, buffalo and small ruminants, was 34,988 in the Ampara district. The number of registered livestock farms in KAL, NAV, and SAM was 3,057, 3,714, and 4,207, respectively in 2019. This information has been derived from the relevant veterinary offices and district office data. The livestock farm registration program was initiated in 2008. The basic data on livestock farms include cattle, buffalo, and small ruminants collected at the divisional veterinary range. This program continues to register newly established livestock farms.

4.2.2 Sample size and data collection

The list of farm registrations available at the government veterinary office was used as the sampling frame, and farmers were randomly selected from three ranges in equal proportions. This study was conducted among small and large-scale livestock farmers who maintained cattle and buffaloes. Cattle owners were selected from three veterinary ranges. The study was conducted for a period of one month in September and October 2019. Data was collected from farmers through a questionnaire on rearing cattle and buffalo, which took approximately 20 minutes per interview by “face to face” survey in their own language (Tamil). This questionnaire was used to collect all the required information for the purpose of the study. The questions concentrated mainly on social factors, farm factors, training programs, FMD vaccination, FMD outbreak, and the number of animals vaccinated for FMD.

4.2.3 Data analysis

The data collected from the study were imported and analyzed using the statistical software STATA 15. The Tobit regression model was used for the animal-level vaccination coverage and, a probit regression model was used for participation in vaccination.

The Tobit model allows regression where the dependent variable is censored data, meaning that a substantial fraction of the observations on the dependent variable take a limited value. The Tobit model apply for the dependent variable is a mixture of observations with zero or positives values (Cameron and Trivedi, 2010). The Probit model is a type of regression where the dependent variable can take only two (1 or 0) alternatives (Damodar, 2015).

Probit model applied for the vaccination participation as dependent variable contains data that are binary responses (0 or 1).

$$y_i = \beta_0 + \beta_1 x_{1i} + \cdots + \beta_2 x_{2i} + \varepsilon$$

$$y_i = \beta_0 + \beta_1 . social\ factors + \beta_2 . farm\ factors + \varepsilon$$

$$Note: \beta_0 - constant, \beta_1, \beta_2 - coeffient\ of\ social\ and\ farm\ factors, \varepsilon - error\ term$$

Tobit model used to describe the relationship between a non-negative dependent variable. Y_i and one or more independent variables X_i. Tobit model is an econometric model in which the dependent variable is censored because values below zero are not observed.

$$y_i = \beta_0 + \beta_1 x_{1i} + \cdots + \beta_2 x_{2i} + \varepsilon$$

$$y_i = \beta_0 + \beta_1 . social\ factors + \beta_2 . farm\ factors + \varepsilon$$

$$Note: \beta_0 - constant,\ \beta_1,\ \beta_2\ - coeffient\ of\ social\ and\ farm\ factors, \varepsilon - error\ term$$

Social factors as age of head of farmer, gender, ethnicity, range, education, income and farmer training. Farm factors include number of animals, farming experience and farm type, knowledge FMD score and hygiene management score. These social and farm factors were considered for probit and Tobit regression model.

To main social and farm factors of mean and standard deviation are summarized in descriptive statistics (Table 4.1). To analyze the score for FMD, knowledge and hygiene management practices related questions were considered. Eight questions for clinical signs of FMD, disease transmission, and age of vaccination were included to evaluate knowledge on FMD (Table 4.2). To determine the score for knowledge, true, false, and do not know answers were given. A correct answer was given one mark, and incorrect and did not know answers were considered zero. Five basic hygiene management questions were asked to estimate the score of farm practices, for which yes / no answers were given as responses.

4.3 Results

4.3.1 Vaccination coverage, social and farm factors

In the field survey, cattle owners in the NAV range had a higher tendency to participate in vaccination than the other two ranges, KAL and SAM. The animal level vaccination coverage in the three study areas was less than 60.0% (Figure 4.1). In between two ethnicities, the vaccination participation and coverage were higher among Tamil farmers than Muslim farmers in this study area (Figure 4.2). In all three ranges, the gender of the farmers was mostly male (88.3%), and approximately 10 to 15 % were female. The ethnicity of farmers in KAL and SAM was mainly Muslims and Tamils (66.7%) in NAV. The average age of farmers, who were mainly parental, was 47, 38.9% of farmers achieved formal education. The main source of income for farmers was agriculture, private jobs, and livestock. On an average, 25.6% of livestock farmers engaged in private jobs, such as fishing, business, and labor work in building construction in the KAL range (41.7%). The results showed that very few farmers attended the farmer training program (23.9%) conducted by veterinary offices. In SAM range majority of the farmers had more than five-year experience in livestock farming than KAL and NAV, therefore it was considered that they were prioritizing their experience in farming lead to a lower tendency to participate in farmer training program (8.3%). The type of farm system was semi-intensive, but in the SAM range, 55.0% of farms were managed under extensive livestock systems (Table 4.1).

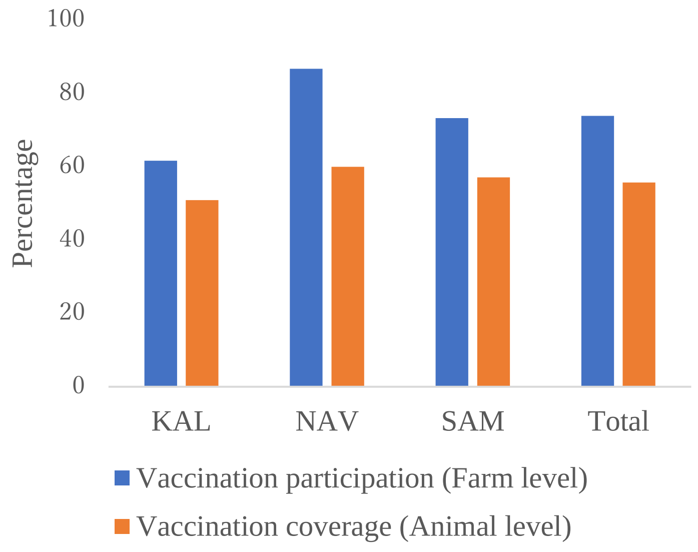


Figure 4.1 Farmers' vaccination behavior on vaccination participation and vaccination coverage in 2018

Source: Field survey

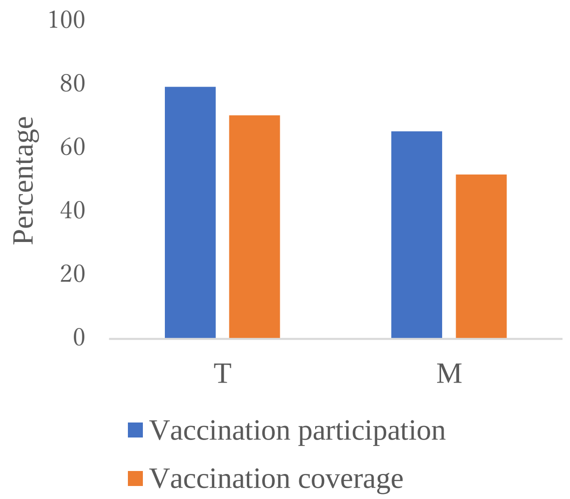


Figure 4.2 Farmers' vaccination behavior on vaccination participation and vaccination coverage between two ethnicities in 2018

Note: T and M are abbreviation of Tamil and Muslim farmers respectively

Source: Field survey

Table 4.1 Summary and descriptive statistics of the main social and farm characteristics between ranges

Variable	Category	Mean	SD	KAL	NAV	SAM
Social factors						
Age	Continuous data	46.9	12.10	49.8	44.2	46.7
Gender (%)	1: Male; 0: Female	88.3	0.32	90.0	85.0	90.0
Ethnicity (%)	1: Muslim; 0: Tamil	62.2	0.48	63.3	33.3	90.0
Range (%)	1: NAV; 0: Other	33.3	0.47	0	33.3	0
Education (%)	1: Formal; 0: other	38.9	0.48	31.7	53.3	31.7
Income source (%)	1: Private; 0: other	25.6	0.43	41.7	21.7	13.7
Farmer training (%)	1: Joined; 0: Did not	23.9	0.42	36.7	26.7	8.3
Farm factors						
Number of animals	Continuous data	18.8	28.65	11.7	16.7	25.0
Farming experience (%)	1: > 5 year; 0: < 5 years	73.3	0.44	78.3	58.3	83.3
Farm type (%)	1: Extensive; 0: other	20.6	0.40	1.7	5.0	55.0
Knowledge FMD score (%)	Continuous data	54.5	2.14	62.9	48.3	52.3
Hygiene management score (%)	Continuous data	49.2	1.47	36.0	73.0	38.7

Note 1: Knowledge FMD score derived from the correct answer of the eight questions regarding FMD (Table 4.2).
Note 2: Hygiene management score derived from correct answers for five questions (Table 4.3).
Note 3: KAL, NAV and SAM are abbreviation of Kalmunai, Navithanveli and Sammanthurai veterinary ranges respectively.
Source: Field survey

4.3.2 Knowledge of FMD and hygiene management practices

Table 4.2 describes the level of knowledge on FMD. Most of the farmers correctly answered the questions about FMD symptoms, such as reduced milk production (68.3%), animal lameness (82.2%), salivation (80.6%), and blisters in the mouth (62.2%). Only 47.8% of farmers believed that the FMD did not transmit from animal to human, most were not able to answer this question. Only 26.1% of farmers correctly answered to disease transmission by air and the age of first vaccination not at one year. This revealed poor knowledge of the mode of disease transmission and the age of vaccination. The mean knowledge of FMD and hygiene management score of 180 farmers was 54.5% and 49.2% respectively (Table 4.1). In the NAV range, most farmers followed basic hygiene management practices, such as wearing boots or slippers when working, using detergents for personal cleaning after work, and separating sick animals from healthy animals (86.7%, 95.0%, and 75.0%,) respectively. However, most farmers had poorly intentions to implement hygiene practices (Table 4.3).

In Table 4.4, the Knowledge explained by social factors were age of head of farmer, gender, ethnicity, range, education, and income source, and those who had joined the farmer training program. We observed that male farmers and farmers with formal education positively influenced knowledge on FMD ($p < 0.01$). However, ethnicity and the income source of farmers did not influence the gain of knowledge. The effect of attending the training program in livestock management was significantly important to improve knowledge on FMD ($p < 0.01$). If the age of farmer increase, the knowledge of FMD also increase ($p < 0.01$). Interaction term was created between age of farmer and attend to present farmer training program as new variable indicate older age farmer attended to present training program was less effective to improving knowledge of FMD score and for young farmer in farmer training program, the FMD knowledge score was higher than aged farmer.

Table 4.2 Farmers' Knowledge of FMD in three ranges

	KAL (n = 60)	NAV (n = 60)	SAM (n = 60)	Total (n = 180)
Reducing milk production (Yes)	65.0	55.0	85.0	68.3
Animal lameness (Yes)	90.0	78.3	78.3	82.2
Salivation (Yes)	83.3	76.7	81.7	80.6
Blindness (No)	63.3	31.7	33.3	42.8
Blister in the mouth (Yes)	40.0	70.0	76.7	62.2
FMD transmitting from animal to human (No)	68.3	36.7	38.3	47.8
Transmit by air (Yes)	60.0	8.3	10.0	26.1
Age of first FMD vaccination at one year (No)	33.3	30.0	15.0	26.1

Note 1: Figures are presented in percentage of the total. (Yes) / (No) next to the relevant questions above are considered correct answers.

Note 2: KAL, NAV and SAM are abbreviation of Kalmunai, Navithanveli and Sammanthurai veterinary ranges respectively.

Source: Field survey

Table 4.3 Hygiene management practices in three ranges

	KAL (n = 60)	NAV (n = 60)	SAM (n = 60)	Total (n = 180)
Use boots or slippers	33.3	86.7	45.0	55.0
Use detergents	53.3	95.0	38.3	62.2
Sick animals not send for grazing	36.7	63.3	26.7	42.2
Separate diseased animals	48.3	75.0	28.3	50.6
Change clothes	8.3	45.0	55.0	36.1

Note 1: Figures are presented in percentage of the total.
Note 2: KAL, NAV and SAM are abbreviation of Kalmunai, Navithanveli and Sammanthurai veterinary ranges respectively.
Source: Field survey

Table 4.4 Social factors influencing on Knowledge FMD score (Tobit model)

Variable	Coef.	SE	z	p-value
Social factors				
Age	0.044	0.014	3.10	0.002***
Gender	1.493	0.457	3.26	0.001***
Ethnicity	-0.418	0.341	-1.22	0.222
Range	-0.975	0.345	-2.83	0.005***
Education	0.924	0.318	2.91	0.004***
Income source	-0.125	0.341	-0.37	0.713
Farmer training	3.733	1.352	2.76	0.006***
Age - Farmer training	-0.058	0.028	-2.05	0.040**
constant	0.958	0.859	1.12	0.265

Note: ** and *** denoted statistical significance at the 5% and 1% level respectively. Number of observations = 180, log likelihood = -373.0, Prob. > chi2 = 0.000

Source: Field survey

4.3.3 Factors affecting FMD vaccination behavior

FMD vaccination behavior described in the level of participation of farmers in the FMD vaccination program (Table 4.5) and vaccination coverage was calculated as the number of animals vaccinated against the number of animals in the herd (Table 4.6). To describe the vaccination behavior for participation and coverage probit and Tobit model were used respectively. Table 4.5 indicate, farmers were keen on the health of cattle for their livelihood, therefore NAV range was significant to vaccination behavior ($p < 0.05$) than other two ranges. Regarding farm factors, the number of livestock and farming experience of more than five years was positively significant ($p < 0.05$). In addition, farmers performed basic hygiene management practices and also contributed to the vaccination programs ($p < 0.1$). The Table 4.6 revealed, at the animal level, vaccination coverage in cattle and buffalo farms was significant to farming experience and knowledge FMD score ($p < 0.05$). Interaction term for Age-Farmer training and Knowledge FMD score-Farmer training were not showed any significance for both vaccination participation and coverage. In this study the FMD score and hygiene management score encouraged the vaccination behavior.

Table 4.5 Social and farm factors affecting FMD vaccination participation

(Probit analysis - farm level)

Variable	Coefficient	SE	Z	p-value
Social factors				
Age	0.001	0.011	0.08	0.934
Gender	-0.231	0.372	-0.62	0.535
Ethnicity	0.091	0.292	0.31	0.755
Range	0.966	0.384	2.51	0.012**
Education	0.447	0.274	1.63	0.103
Income source	-0.502	0.274	-1.83	0.067*
Farmer training	0.309	0.314	0.98	0.326
Farm factors				
Number of animals	0.022	0.011	2.05	0.040**
Farming experience	0.686	0.305	2.25	0.024**
Farm type	0.238	0.368	0.65	0.517
Knowledge FMD score	0.132	0.062	2.13	0.033**
Hygiene management score	0.195	0.108	1.81	0.070*
constant	-1.398	0.696	-2.01	0.045

Note: * and ** denoted statistical significance at the 10%, and 5% level respectively. Number of observations = 180. For probit regression, log likelihood = -74.741, Prob. > chi2 = 0.000

Source: Field survey

Table 4.6 Social and farm factors affecting FMD vaccination coverage

(Tobit analysis - animal level)

Variable	Coefficient	SE	Z	p-value
Social factors				
Age	-0.004	0.208	-0.02	0.986
Gender	-3.696	7.380	-0.50	0.617
Ethnicity	-2.654	5.352	-0.50	0.620
Range	14.916	6.613	2.26	0.024**
Education	4.384	4.998	0.88	0.381
Income source	-3.278	5.487	-0.60	0.550
Farmer training	6.274	5.470	1.15	0.251
Farm factors				
Number of animals	0.109	0.091	1.19	0.233
Farming experience	12.597	5.750	2.19	0.028**
Farm type	12.732	6.511	1.96	0.051*
Knowledge FMD score	2.841	1.183	2.40	0.016**
Hygiene management score	3.282	2.006	1.64	0.102
constant	10.783	12.875	0.84	0.402

Note: * and ** denoted statistical significance at the 10%, and 5% level respectively. Number of observations = 180. for Tobit regression, log likelihood = -864.207, Prob. > chi2 = 0.000

Source: Field survey

4.4 Discussion

The vaccination participation and coverage were recorded in NAV range as 86.7% and 60.0%, respectively, higher than the other two ranges (Figure 4.1). The hygiene management score was significantly higher in NAV (73.0%) than in KAL and SAM, but knowledge FMD score in NAV was only 48.3%. On average, the majority of farmers new the clinical signs of lameness and salivation to identify the FMD from other diseases of cattle, but had poor awareness of the mode of transmission and age of vaccination, which are important factors in controlling FMD among endemic areas. The hygiene management practices were exhibited by the farmers at a relatively lower level (Table 4.3). This result was indicated together with knowledge FMD and hygiene management score as important factors to motivate farmers to facilitate both participation in vaccination and animal level vaccination coverage.

Table 4.4 revealed, younger generation is important for the future farmer training to improve the knowledge of FMD and effective strategy for successful farmer awareness program. The vaccination behavior for participation and coverage were higher among Tamil farmers, because the intensive farm management system, main income source (private) and attended to farmer training program were significant (Chapter 3, Table 3.1). Our results showed that knowledge FMD and hygiene management scores are obviously important to encourage farmers to participate in FMD vaccination behavior at the compulsory vaccination implemented by the DAPH. In traditional dairy farming systems cattle and buffalo are owned and managed by men and women, but the majority were men who played an important role in disease prevention and control.

The total number of cattle and buffaloes in the farm also facilitates participation in FMD vaccination. If the farms have a higher number of animals, they tend to be vaccinated as protection from the outbreak of FMD. These farmers knew about the impact and economic loss due to FMD in the Ampara district. Some family members are hereditarily involved in livestock family farming as the main source of income. Farming experience was more significant for determining vaccination behavior. They were committed to taking care of the health of animals from the FMD outbreak.

Farmers' income, if mainly from private jobs, did not consider vaccinating the animal for FMD because they were too involved with any type of job, such as business, self-employment, fishing, building work, and carpentry work. They were busy with their work. This group of livestock farmers was not interested and reluctant to take care of animal health. This type of farmer should be given priority in training program and protecting other neighboring farm animals. Livestock farmers in the KAL range were more involved in private jobs for their main income source than other study areas. Livestock is not the main income source in the KAL range, which located in the Kalmunai municipality area. The farmers were busy in their private work therefore, the farm and animal level vaccination percentages were less than the other two ranges. Several socio-farm factors were identified as influencing the participation in vaccination and coverage such as range, main income source, number of animals in their farm, farming experience, type of management, knowledge of FMD, and hygiene management practices.

Farmers missed the opportunity to vaccinate all animals in their herd during the vaccination period due to the livestock farming system being mainly extensive and semi-intensive. Some farmers moved their animals from one range to another for feeding in uncultivated land or in the jungle area. Animal movement is an important concern in FMD spread from one range to another or district to district. To avoid this situation, prior planning and coordination with farmers is essential to vaccinate all suitable animals. The vaccination campaign should be supervised and monitored by veterinary surgeons in their assigned areas. Most of the animals are indigenous breeds and difficult to control during administration of the FMD vaccine in large herd extensive systems. Suitable animal restraint should be considered to ensure safe handling of animals and vaccinators during vaccination programs.

Effective communication between farmers and veterinary surgeons could play an important role in achieving optimization of vaccination strategies (Hall and Wapenaar, 2012). The veterinary surgeon's role is significant in promoting awareness of a need to vaccinate, and an improved veterinary surgeon-farmer the relationship enhances the performance to accept the vaccination. To improve farmers' knowledge of FMD and basic hygiene management practices, livestock educational training programs are an important tool to control the FMD outbreak in this study area. The acceptance of vaccination by farmers will mostly depend on the level of awareness of vaccination and improvement in their knowledge of FMD by capacity building of farmers on FMD control.

The present farmer training is not enough to control FMD outbreak and training mainly focused on producing milk value addition, poultry management, cattle and poultry feed formulation and pasture, fodder cultivation and cattle, and goat management. Therefore, this study clearly showed that the importance, identification, mode of transmission of FMD, vaccination, and hygiene management practices of livestock farms should be considered for the farmer training awareness program to prevention and control of FMD. Some farmers believed that the FMD vaccine caused abortion in any period of pregnancy, reduced milk production, and weakened the animal. Farmers believed that FMD did not cause death to cattle and buffaloes and could be treated by antibiotics, not by the FMD vaccine, few farmers even treated the FMD affected animal by traditional methods in rural areas. The use of antibiotics during FMD outbreaks reported in other developing countries (Nampanya et al., 2016; Young et al., 2017). Misperception about the FMD vaccine should eliminated among farmers to accept the vaccination. Prioritizing and organizing regular training programs accommodating rural farmers is a must (Rezvanfar, 2007).

For the control of the FMD outbreak, farmers should be of aware the economic importance of the FMD. Currently, in the eastern province, a mass vaccination program is being implemented by the DAPH. To maintain the herd immunity for FMD, regular vaccination intervals are essential for the strategic control program of the World Animal Health Organization (OIE) and following the steps of PCP-FMD is important to eradicate the disease in Sri Lanka (FAO, 2018b). This study revealed, that to achieve adequate vaccination coverage, farmers' knowledge and hygiene management practices needed to be identified for successful FMD control programs. That the disease control authority and policymakers should consider to addressing these issues is an important finding of this research.

4.5 Conclusion

FMD is regularly reported every year among small and large herd traditional dairy farms in the eastern province, Sri Lanka. Farmers' knowledge of FMD and hygiene management practices were linked with participation in vaccination and vaccination coverage in this area. There is a need to educate farmers on the impact of FMD and associated control measures, including vaccination and hygiene management in farmer training awareness programs. Farm factors of having a higher number of animals, farming experience of more than five years, knowledge on FMD and hygiene management practices contributed to significant enhancement in participation in vaccination and vaccination coverage. Animal health extension strategies should be properly organized, and the current data management system of cattle and buffaloes should be improved in each range to enable more reliable determination of vaccination coverage for control of FMD in high-risk areas in Sri Lanka.

CHAPTER 5

Farmers' embedded indigenous behavior and adoption factors for the control of foot and mouth disease

5.1 Introduction

Livestock act as livelihoods of traditional societies and among the poor. Livestock represent a savings of assets that are reserved for use in the future and contribute to nutritional security of a household and fulfill the high value of nutrition (Dorward et al., 2005). Livestock contribute many important roles in traditional farming systems. There is need to improve animal health and productivity in developing countries. Livestock disease risk can be connected with the socio-economic status of the farmers (Cappai et al., 2018). Foot and mouth disease (FMD) is the major livestock health issues causing socio-economic impact on sustainable livestock farming and also the global status of FMD closely follows poverty indicator (FAO, 2002).

During FMD outbreak, farmers quickly attend to treat FMD clinical signs using indigenous behavioral practice on their judgement, accessibility of source, past experience about effectiveness. The choice of a farmer between the tradition and modern system of treating animal diseases revealed that half of cases were treated themselves (self-treated), using traditional, shared community knowledge or advice of a knowledgeable person from farmer society (Mangal, 2015). Folk knowledge (traditional knowledge) that particularly embedded among traditional famers, and passes generation to generation with regard to treating their animals most strongly by behavioral and normative beliefs on traditional animal healthcare practices. Traditional practices of treating animal remains prevalent in low- and middle-income countries (Nye et al., 2021).

Treatment behaviors are depending on economic factors and that common default to home remedies and self-treatment is primarily a result of economic influence (Ghotge et al., 2002) or poor access to veterinary services (Upjohn et al., 2014). Farmers' indigenous innovations arise from and are a component of traditional farmers' traditions in coping with ordinary animal husbandry issues (Ayalew and Mulatu, 2005). A survey of working equids in Ethiopia indicated that 10.5% employed traditional medicine, 31.6% visited veterinary clinics, and 57.9% did nothing when their animal exhibited signs of disease (Niraj et al., 2014). People in rural areas prefer self-treatment to service delivery because they are more comfortable with what they are familiar (Nye et al., 2021). A high frequency of veterinary consultation was discovered among dairy farmers in northern India, indicating a better veterinary-client interaction (Kumar and Gupta, 2018). The relationship between disease prevalence and farmer behaviors, which were influenced by different factors relating to farms and farmer characteristics such as demographic factors, socio-economic factors and social network with other stakeholders (Hidano et al., 2017a). Livestock are managed by humans, it is not surprising that culture and behavior can influence the epidemiology of animal diseases (Hidano et al., 2018). The studies have found that farmer develops different management practices and control strategies based on their social and cultural situation and disease understanding (Hidano et al., 2017b).

Behavioral changes should be encouraged in order to adopt effective method of control. Romer (1990) found the technological progress is the ultimate source of long-term economic growth. The differences in technology levels among countries depend on per capita income (Caselli, 2005). The determinants of the adoption of agriculture technologies found in existing studies on development economic in social learning from learning (Foster and Rosenzweig, 2010).

Pannell (2008) showed, the conditions necessary for an individual farmer to adopt innovative farming system. Traditional knowledge is best viewed as a whole system of knowledge that involves decision-making, adapting to change, and disseminating knowledge and good practices, rather than just a collection of facts or ideas (Warren, 2011).

Proper biosecurity, hygiene management practices and regular FMD vaccination are the important famer behavior for the control of FMD. By improving the farmer awareness towards immediate report of FMD cases, animal movement management, better farm management and involvement in vaccination program are considered for FMD control in all over the world. In Sri Lanka, there is a gap in the study of farmers' embedded behavior on self-treatment and FMD prevention methods.

The objectives of this chapter,

1) To identify farmers' traditional practices for FMD control
2) To motivate the farmers to change their behavior in order to adopt more effective ways of preventing FMD outbreak

5.2 Materials and method

5.2.1 Data collection and analysis

The study was conducted among 180 farmers, but for the open questions on FMD treatment and prevent only 87 farmers were interviewed in three ranges. The number of samples of free writing questions were from KAL, NAV and SAM were obtained 34, 38 and 15 respectively in three ranges. Among these famers' community, ethnicity wise 42 and 45 Tamils and Muslims were considered for the study purpose to identify the embedded behavior to FMD control practice [1)]. Text mining method can be used to elicit the farmers behavior to FMD treatment and prevention. The KH Coder software was applied for the purpose to identify farmer embedded behavior of frequency and co-occurrence network for total sample and two ethnicities.

5.2.2 Text mining

Text mining is a method of quantitative analysis of latent factors in text data, such as appearance of frequency of words, correlation of co-occurrence, appearance tendency, time series, etc., by dividing the text data into words and phrases (Tan, 1999). Text mining techniques applied for the free descriptions of questionnaires analysis (Yamanishi and Li, 2002). Text mining has become important research area. Three steps are included in text mining; text pre-processing, text mining operations and post processing. Text pre-processing involves in data selection, classification, feature extraction and text normalization. The second steps deal with different text mining techniques like clustering, association of rule detection, visualization and term frequency (Figure 5.1). In third step, alterations are made on the data through text mining functions like evaluations and choice of knowledge, analysis and visualization of knowledge (Salloum et al., 2018)

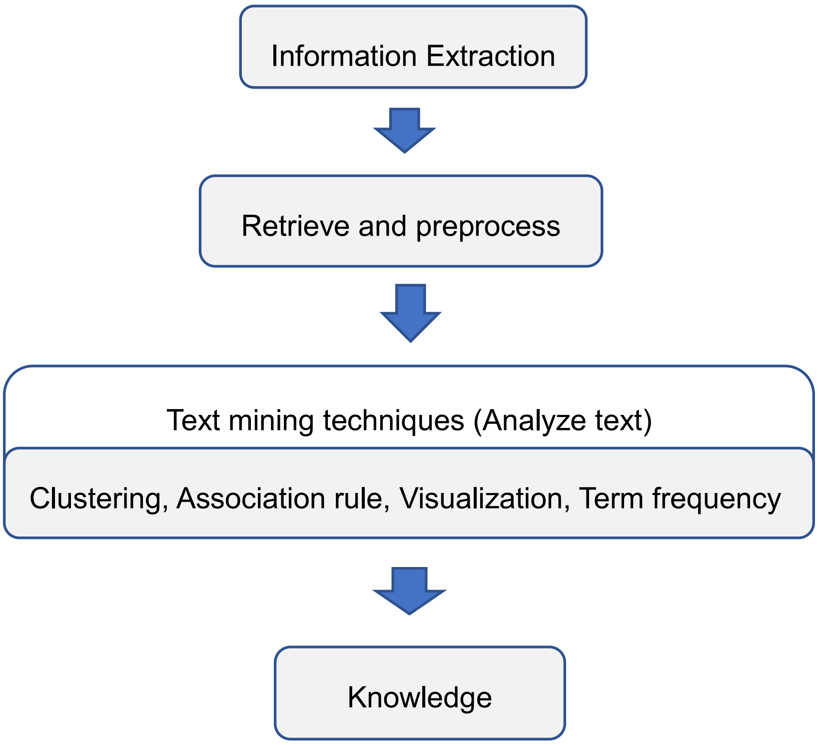


Figure 5.1 Frame work of text mining process
Source: Modified diagram from Salloum et al., 2018

5.2.3 KH Coder

To analyze farmers' behavior, text mining was performed on keywords extracted from free writing for the open-ended questions. Term frequency was calculated for the number of occurrences of each target keywords in an entire sample of text and separately for two ethnicities. KH Coder Version 3 applied for this task in Windows (Higuchi, 2017). KH coder uses the Jaccard coefficient to determine the degree of word to word co-occurrence and creates a network visualization (Higuchi (n.d)a). In this network lines were connected with the words closely related with each other. KH coder also displays networks that are most closely associated with each other as "subgraph" through color coding (Higuchi (n.d)b). Co-occurrence means to how many times high frequency words, used often and regarded as “keywords” appear in the text proximity to other high frequency words. In this context, co-occurrence also means close relationship between words. The co-occurrence index ranges from 0 to 1, and 0 means corresponding to the lowest occurrence and 1 for the highest occurrence (Yoshikawa et al., 2019). Co-occurrence was calculated using Jaccard similarity coefficient (Lebowitz et al., 2020).

5.2.4 Jaccard coefficient

Jaccard coefficient has been introduced in the distribution of the flora (Jaccard, 1912). Determination of the association between two words with Jaccard coefficient (J). Jaccard index is a name often used for comparing similarity, dissimilarity and distance of the data set. Measuring Jaccard similarity coefficient between two data sets is the result of division between the number of features that are common to all divided by the number of properties (Niwattanakul et al., 2013). Further Jaccard similarity can be measures between finite sample sets and is defined as the size of the intersection divided by the size of the union of the sample sets.

$$J(A,B) = \frac{|A \cap B|}{|A \cup B|}$$

Jaccard distance is non-similarity measurement between data sets. This can be calculated by the inverse of the Jaccard coefficient which is obtained by removing Jaccard similarity from 1. It refers that Jaccard distance is obtained by subtracting the Jaccard coefficient from 1, or equivalently, by dividing the difference of the sizes of union and the intersection of two sets by the size of the union (Niwattanakul et al., 2013).

$$d_j(A,B) = 1 - J(A,B) = \frac{|A \cup B| - |A \cap B|}{|A \cap B|}$$

5.2.5 Co-occurrence network

Regarding the relative strength of the co-occurrence, value of Jaccard coefficient is calculated with respect to all combinations of the words in the text. The Jaccard coefficient of the co-occurrence between any word X and any word Y is calculated in the following equation (Shimodaira and Fukuda, 2014).

$$J = \frac{A}{(A + B + C)}$$

Here, A- refers the number of sentences where both word X and Y appear at the same time

B- refers the number of sentence where only word X appears

C- refers the number of sentence where only word Y appears

The KH Coder automatically calculates the value of the Jaccard coefficient, and draw a figure displaying the network between words. In network figure there are two patterns: network based on "centricity" of the words and network with 'sub graph" detection.

In centricity analysis, the network shows the extend which each word plays a central role in text. Each word distinguished by different color. In order of red, pink, white, light blue, with red indicates the greatest.

In sub-graph detection, the words are strongly linked to another. Each group differentiate by color: green, yellow, blue, red, etc. A white color indicates that is an independent word that does not form a group with other words. A solid line connects words include in the same group. Words include in different groups are connected by a broken line.

5.3 Results

5.3.1 Farmers' activities and frequency distribution for treatment and prevention of FMD

There were different treatment and prevention activities identified among sample farmers during FMD outbreak. Table 5.1 showed farmers thought FMD vaccine and visit to veterinary office to inform FMD outbreak and acquired advice. Simultaneously, farmers engaged different embedded indigenous practices to treat FMD wound lesions such as wash the lesions with salt water or warm water. As a fly repellent some farmers practice burning the cow dung with waste dry fish. Some farmers used as local application with old engine oil, neem oil, wound powder. Alum crystals also used as traditional method of treating FMD lesions. Also identified few farmers involved in cleaning the farm, hygiene practices, separate sick animals and water sanitation.

Table 5.1 Description of farmers' activities for the treatment and prevention of FMD

Farmers' activities	Description
vaccine	participate in vaccination program
vet office	visit to vet office to inform FMD and to get advice
traditional practice	do not mention the specific and mix with other traditional practices
engine oil	burnt engine oil apply to hoof lesions
dry fish	use dry fish waste for smoke with dry cow dung
wound treatment	treat FMD wound lesions
clean farm	keep the animal and farm as clean
salt water	use salt water to wash hoof lesions
antibiotic	treat with antibiotic
do not know	not mention the FMD treatment and prevention
neem oil	apply neem oil for wound lesion and use as fly repellent
wound powder	apply medicated wound powder to hoof lesions
warm water	use warm water to wash wound lesions
alum	treatment for mouth lesions
detergent	soap water
rubbing with lemon	cut the lemon and rubbing with mouth lesions
separate animal	separate sick animals
water sanitation	use clean water

Source: Field survey

When interviewed the farmers on perception of treatment and prevention of FMD, higher percentage of farmers (34.2%) answered, vaccine was important and report to veterinary office also essential (Table 5.2). The use of antibiotic to treat FMD wound to prevent secondary infection also identified for treatment and prevention of FMD. Table 5.2 indicated the farmers' self-treatment and their indigenous behavior linked with FMD vaccination and contact with veterinary office.

Table 5.2 Farmers' response and frequency distribution for total sample (N=87)

Farmers' activities	Frequency	Percentage (%)
vaccine	76	34.2
vet office	34	15.4
traditional practice	20	9.0
engine oil	17	7.7
dry fish	11	5.0
wound treatment	11	5.0
clean farm	10	4.5
salt water	9	4.1
antibiotic	8	3.6
do not know	8	3.6
neem oil	5	2.3
wound powder	5	2.3
warm water	2	0.9
alum	1	0.5
detergent	1	0.5
rubbing with lemon	1	0.5
separate animal	1	0.5
water sanitation	1	0.5

All word frequencies were selected for analysis. The percentage was obtained each activity of farmers' dividing by total frequencies.

Source: Field survey

Table 5.3 illustrated the comparison of farmers' behavior to FMD between two ethnicities in study population. The word frequency for vaccine was almost similar but word frequency percentage was higher for Tamil (37.3%). The attending to veterinary office during FMD outbreak was higher for Muslim. All farmer behavior was represented among two ethnicities but, use of warm to wash FMD lesions were seen among Tamil.

Table 5.3 Farmers' response between two ethnicities for the treatment and prevention of FMD

Farmers' activities	Frequency		Percentage (%)	
	T	M	T	M
vaccine	38	39	37.3	32.5
vet office	10	24	9.8	20.0
traditional practice	7	13	6.9	10.8
engine oil	9	8	8.8	6.7
dry fish	7	4	6.9	3.3
wound treatment	3	8	2.9	6.7
clean farm	4	6	3.9	5.0
salt water	5	4	4.9	3.3
antibiotic	3	5	2.9	4.2
do not know	5	3	4.9	2.5
neem oil	3	2	2.9	1.7
wound powder	2	3	2.0	2.5
warm water	2	-	2.0	-

The minimum word frequency was considered as two for comparison of two ethnicities in study area.
Source: Field survey

5.3.2 Co-occurrence network for farmer behavior

The co-occurrence network was applied for of total samples (N=87) and two ethnicities: Tamil (N = 42) and Muslim (N = 45). In the network, words in the subgraph are connected by solid line. When occurrence with words in other subgraph, they are connected by broken line. Minimum word frequency and Jaccard coefficient was considered for the map was 2 and 0.1 and Jaccard coefficient indicate in each line between two words.

Figure 5.2 described the frequency for vaccine was higher than other farmer behavioral practices. The Jaccard coefficient between vaccine and vet office was higher (0.36) than other coefficient between two practices. In total sample, the vaccine, vet office, traditional practices and wound treatment were strongly linked together in one group.

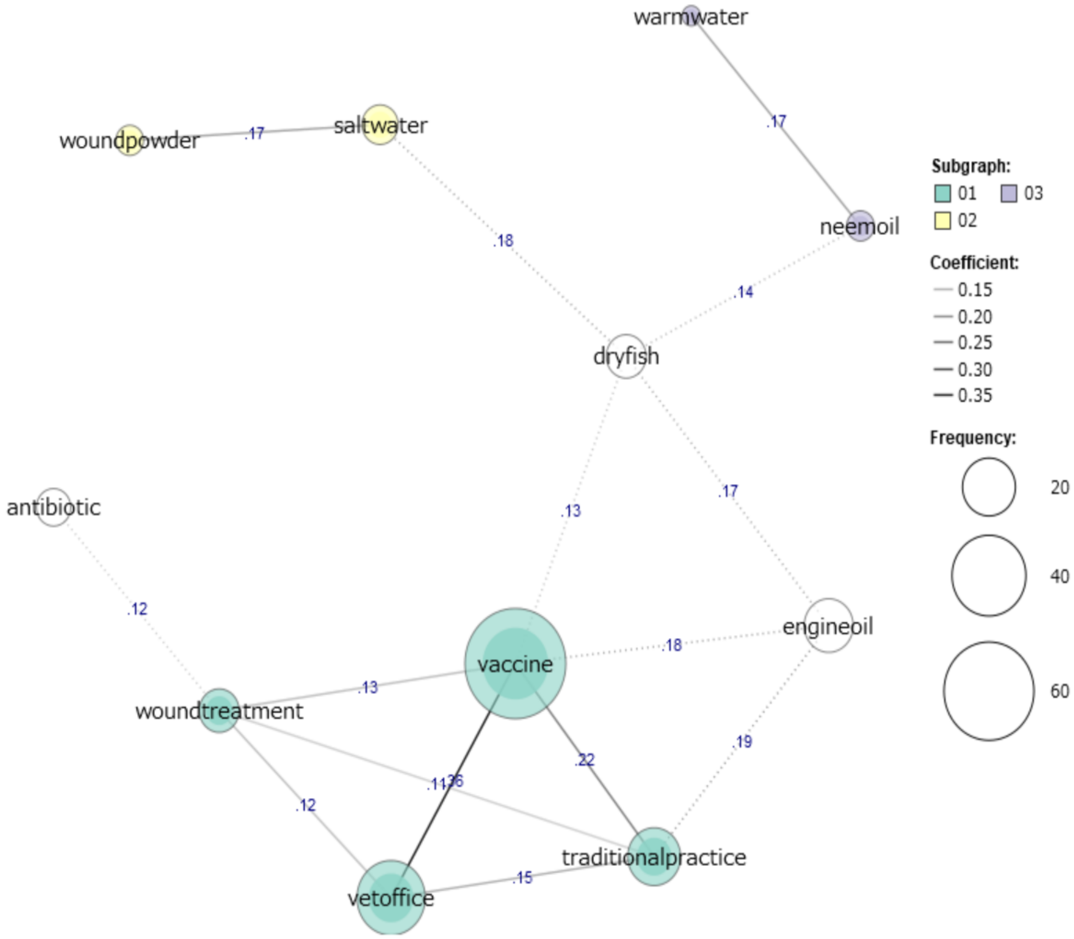


Figure 5.2 Co-occurrence network of total sample for the treatment and prevention of FMD (N = 87)

Figure 5.3, frequency of vaccine was higher and linked with vet office among Tamil. The practice of neem oil, dry fish smoking and wash with warm water treatment were associated with one sub group, but among Muslim only two groups of practices were identified. The Jaccard coefficient between vaccine and vet office was 0.54 in Muslim but, among Tamil coefficient between vaccine and vet office was 0.20. This indicate that association between vaccine and vet office practices more attached among Muslim than Tamil. Practice of old engine oil, dry fish smoke, salt water and engaged in wound treatment were associated in one group (Figure 5.4). Among Tamil farmers, traditional practices and engine oil linked together and Jaccard coefficient was 0.33 (Figure 5.3).

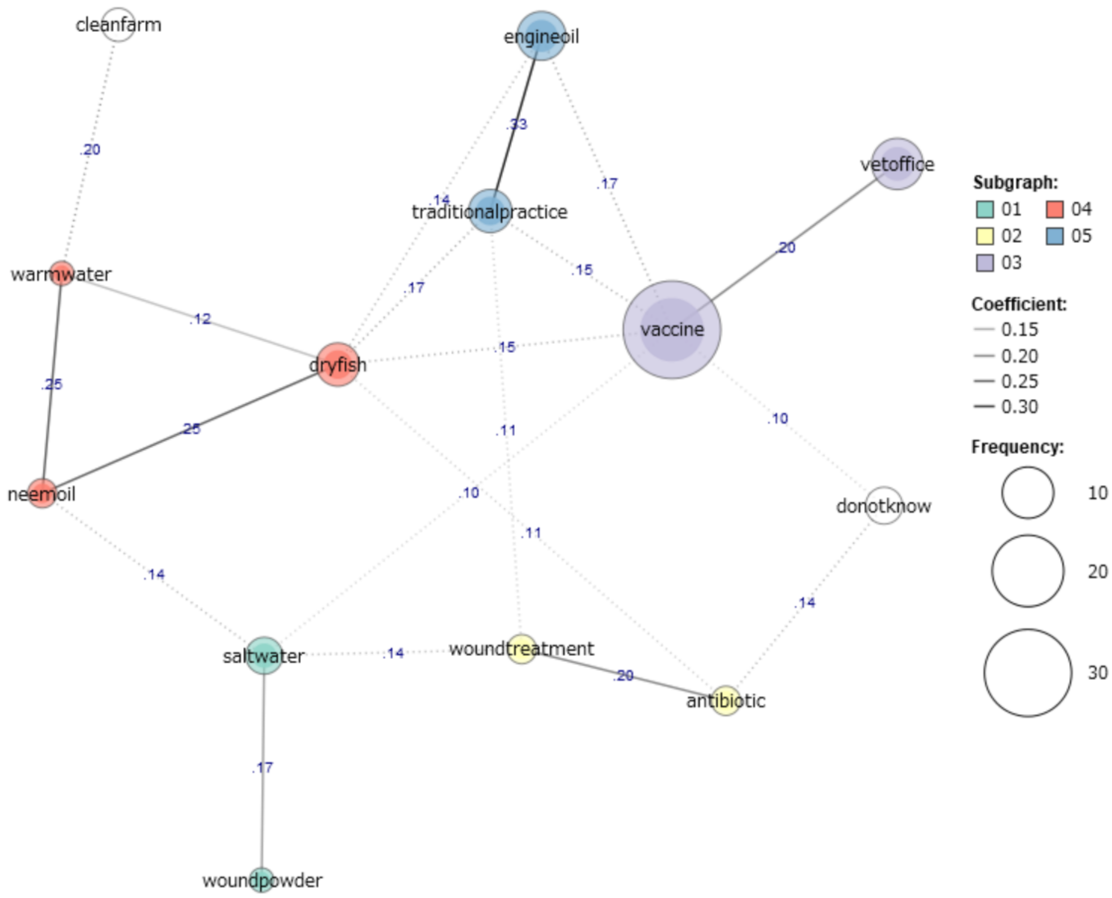


Figure 5.3 Co-occurrence network of Tamil for the treatment and prevention of FMD (N = 42)

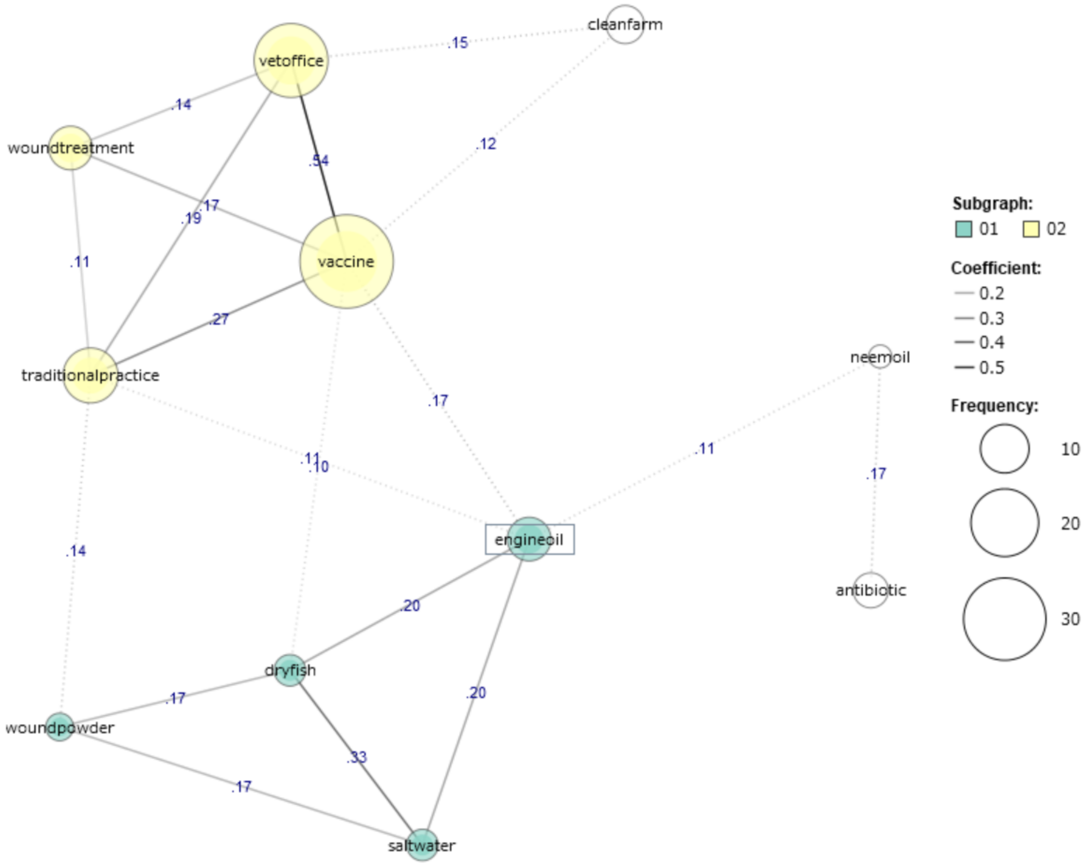


Figure 5.4 Co-occurrence network of Muslim for the treatment and prevention of FMD (N = 45)

5.4 Discussion

Livestock diseases are causing economic losses to rural farming system. Livestock owners are traditionally considered the practices to take care of animals. FMD was fairly well-known disease among cattle farmers, and they were familiar with traditional methods of caring and treatment of animal disease. The open questions administered to aware the valuable information of indigenous behavioral approaches of farmers towards FMD treatment and prevention of FMD among farmers at the time of outbreak of disease. Furthermore, these practices are useful to identify the cultural and behavioral differences between two ethnicities. Indigenous treatment and prevention of FMD practiced by the farmers, when the cattle exhibit the symptoms of FMD such as saliva dropping from mouth, fever, blister tongue and teat and between the hoof. Most of the farmers respond FMD vaccine and contact with veterinary office to acquire advice for treatment of FMD, while engaging own traditional practices. Cattle farmers involved in isolate the infected animal with different traditional practices like applying burnt engine oil, neem oil to treat FMD lesions. When FMD clinical signs appeared, farmers tend to treat animals without immediate report to veterinary authority for the quick action of disease notification for the control of spreading of disease from one area to another. Immediate reporting, of animal disease by the farmers is crucial for controlling and eliminating the disease by animal health authority (Motta et al., 2019; Palmer et al., 2009). There was evidence of under-reporting of FMD in Sri Lanka cause continuous outbreak (Gunarathne et al., 2016). Due to the nomadic patterns of cattle movement and if the animals were in remote locations, which restrict the farmers to contact immediately with local veterinary authority for the immediate action. This situation also farmers trying to treat FMD clinical signs. Semi intensive and extensive cattle management, movements of animals are not controlled and also close contact with animals from other herds in grazing area. This situation aggravates the FMD outbreak very fast.

During FMD outbreak, farmers clean the lesions in mouth and hoof by salt water, warm water to decrease the pain associated with lesions. In Afghanistan, the same method of traditional treatment practice as stand the infected animals in a stream or river to clean foot lesions commonly used. Also, application of alum crystals for FMD mouth lesions in infected cattle was reported as typical local treatments (Osmani et al., 2021). Localized treatment by rinse the lesions with alum practiced in Egypt (Mahmoud et al., 2019). The cattle farmers frequently apply wet alum crystals in mouth and tongue lesions in study area. This indigenous method offers the advantages of relieving discomfort and lameness associated with open erosions. However, this kind of farmers' embedded behavior could be a risk factors for the spread of FMD virus in endemic regions through releasing the virus into the water, farm environment and livestock location (Dukpa et al., 2011). Among the cattle farmers in Cambodia, reported that used traditional method to treat by several types of herbs, with some use engine oil (23%) to clean the FMD wound lesion and deterring the flies and farmers allow the infected cattle to walking through mud to cauterize the pain arising from lesions (Sieng et al., 2021). There was an evidence of applying engine oil to treat skin diseases as private treatment was effective among livestock farmers in Japan, but it is not appropriate way of practice (Makita, 2021). Use of antibiotics to treat FMD is common practice to prevent secondary infection and cure the animal from weakness. Another study found that delayed reporting disease and potentially large-scale inappropriate use of antibiotics for treatment for FMD cases (Young et al., 2017).

The traditional usage of soda ash solution (sodium bicarbonate), honey and finger millet flour were used to management the FMD lesions for fast healing in a dairy herd as ethnoveterinary remedies documented in Kenya (Gakuya et al., 2011). In study of Mangal (2015) found to treat FMD: allow the animal stand in mud, mix alum in water and make the animal drink and apply on the leg and mouth and boil the neem leaves in water and wash leg and mouth and also make a smoke of the neem leaves around the animals.

To control FMD in Sri Lanka, there is no culling system for infected animals, and animal movement restrictions are also not implemented during the FMD outbreak in the traditional extensive farming system. As a result, cattle farmers are attempting to cure affected animals for FMD lesions, with the expectation that cattle will return to normal following FMD infection. Farmers have developed a behavioral practice of treating animals without informing the authorities. This will aid in the spread of the disease throughout the region. Changes in indigenous ingrained behavior are critical for the success of FMD control approaches in preventing and controlling the disease. Efforts to improve biosecurity measures through training of traders, livestock industry professionals, and both commercial and smallholder farmers resulted in a change in animal owner behavior (Windsor et al., 2011). To reduce the FMD-risk famer behavior is important to for prevention of disease. Farmers' indigenous behavior must be changed through knowledge-based intervention through farmer training and mass public awareness education programs on disease risk management for FMD, as well as motivating farmers to report FMD clinical signs to veterinary authorities, adoption to improving both hygiene and sanitation, as well as FMD vaccination strategy are necessary for sustainable FMD control.

5.5 Conclusion

Study on farmers' indigenous embedder behavior provided helpful information on FMD treatment and control measures during outbreak, which could be used to improve the future implementation of method to control FMD by changing the risk-behavioral practices. Contact with veterinary office for FMD vaccine and report the disease is more linked in co-occurrence network. This study clearly showed with vaccine, farmers engaged in different types treatment practices to cure and protect the animals without immediate report of the disease to prevent further FMD spread. To change or stop the unwanted practices should be avoid by improving the farmers knowledge on FMD and consider the proper way of control method. Emphasize to adopt the farmers to regularly vaccinate, restrict the animal movement during FMD endemic and motivate the farmers to hygiene management practices.

Note:

1) Total sample size and collection of data were summarized in chapter 1

CHAPTER 6

General discussion

Foot and mouth disease (FMD) is the one of the endemic transboundary animal diseases that have significant socio-economic importance in Sri Lanka. Sufficient epidemiological and socio-economic information at the national level is important on how to control the disease. The general objective of the research was to clarify the present FMD status and related farmers' behavior, provide inputs for integrated effective control strategy in Sri Lanka. Based on the related literature review in Chapter 1, dairy farmers' knowledge, attitudes and practices, FMD vaccination and farmers behavior towards FMD control were identified for the successful eradication in FMD free countries. In Sri Lanka, there is research gap in these points, therefore the specific objectives were to:

1) Identify the farmers' knowledge, attitudes and practices (KAP) of FMD,
2) Explore the factors affecting vaccination behavior of farmers to control FMD
3) Clarify the farmers' embedded traditional behavioral practices for the treatment and control of FMD.

National policies on transboundary animal diseases (TAD) to be guided by international obligations, agreements and priorities. Feasible intervention of effective animal disease epidemiology is observed as a limitation in eradication of TAD (Otte et al., 2004).

The Chapter 2 described the FMD epidemiology and outbreak occurrence pattern also clear evidence for the endemic and causing socio-economic impact to livestock industry in Sri Lanka. Based on the findings of Chapter 3, the majority of the farmers had no intention to practice diseased animal isolation and animal movement restriction for grazing during FMD outbreak.

Livestock production in developing countries is constrained by many factors including animal diseases, limited feed resources, lack of marketing of livestock products and poor herd management. Currently available and accessible advisory services is still needed in order to improve farmers' knowledge and livestock production system (Byarugaba et al., 1998). Farmer training is one the intervention strategies to identify animal related problems and challenge as well as potential solution (Vaarst et al., 2007). Experimental learning applied in developing countries for improvement of livestock production to identifying constraints and finding solutions among groups of farmers together with scientists and extensions officers (Sones, 2003). Socio-economic factors that influence the adoption of new agricultural technologies and management practices of farmers (Mellon-Bedi, 2020). Farmers' knowledge, attitudes and practices (KAP) gap were identified for one the reason for spreading FMD in Sri Lanka as indicate in other developing countries such as Cambodia, Kenya and India. FMD control awareness programs aimed at increasing farmers' KAP to improve livestock health and management practices among dairy farmers. The present livestock extension services should be considered more broadly to disseminate the knowledge of FMD by organize the training to farmers.

The Chapter 4 describe the farmers' vaccination behavior on participation and coverage were not reach the satisfactory level to prevent FMD in study area. Among South east Asian countries Indonesia and Philippines have achieved freedom from FMD. To achieve successful eradication of FMD in Indonesia, livestock authority has divided the country into three zones such as; disease-free zone, suspected zone and infected zone (Blacksell et al., 2019). In disease free zone restriction of animal movement and quarantine were introduced and routine surveillance was implemented in suspected zone. Mass vaccination program was carried in infected zone. More than 3-month-old cattle and buffalo vaccinated 3 time per year and pigs were vaccinated only in infected zone and also small ruminants were vaccinated voluntarily. Vaccination coverage was maintained 80% minimum. Ear markings technique were used to identify the vaccinated animals. Intensive epidemiological surveillance was carried out monitor the reappearance of FMD cases. This program successfully declared the free of FMD after 3 years in Indonesia. This is good experience FMD can be eradicate by vaccination behavior of farmers' and related control measures.

To maintain the satisfactory vaccination coverage could be evaluated through record keeping and vaccination cards as recommended in the FAO-OIE post vaccination monitoring (Ferrari et al., 2016). During vaccination campaign 100% coverage is impractical (León et al., 2014) due to small calves (less than 3 months) and pregnant animals in their third trimester are left unvaccinated during vaccination program. The progressive control pathway for FMD (PCP-FMD) has developed to facilitate FMD control to reduce the impact of disease. Sri Lanka has been identified in stage 1 of PCP in 2016. India has achieved stage 3 in PCP for control of FMD (Audarya, 2020). Vaccination strategy is line with PCP approach for endemic areas as promoted for FMD control. Activities in stage 1 include training needed to support field and laboratory, information system for field work, prompt report of disease and decision making, updating the legal regulations for animal disease control and veterinary services.

The Chapter 5 describe the farmers' indigenous embedder behavior provided helpful information on FMD treatment and control measures during outbreak, which could be used to improve the future implementation of method to control FMD by changing the risk-behavioral practices. Changes in indigenous ingrained behavior are critical for the success of FMD control approaches in preventing and controlling the disease. Farmers' indigenous behavior must be changed through farmer training and mass public awareness education programs on disease risk management for FMD and motivate the farmers to acceptable control pathway.

In the long run, compensation for farmers must be considered for sustainable disease control. In developed countries consider the compensation for farmers for animal destroyed under disease eradication program is required by the legislation not to exceed the market value for healthy animals. Hennessy and Wolf (2015) consider that compensation to ensure early reporting of disease but not so large as to discourage appropriate levels of biosecurity effort. Policies effects farm incentives through indemnity payments for infected animals, movement and testing restriction, sanitary licensing requirements, output grade and standard (Wolf, 2005).

Theory of planned behavior discuss the way of possibility of changing human behavior with knowledge information, education, income, etc. (Ajzen, 1991). By Incentives like farmer awareness through extension and change attitudes; farmer change their traditional behavior towards FMD control, through proposed intervention. The similar approach identified by Mankad (2016) illustrate that cognitive thinking and attitudes of farmers change the biosecurity behavior. The principal-agent theory can apply in animal disease management; principal (veterinary authority) wants to delegate task to agents (farmers). The agents have information on performing biosecurity practices and vaccinate the cattle to prevent FMD spread. The information gap between farmers (agent) and the government (principal) lead to asymmetry information, therefore to motivate the farmers to attain proper knowledge and information by knowledge intervention program is essential. Martimort and Laffont (2002) describe the model of principal-agent serves to frame and highlight key consideration of both farmer and government decision. Farmers who seek to reduce predicted disease costs, readiness to devote the proper amount of effort in disease prevention and management, if a government provides indemnities to farmers for infected animals (Hennessy and Wolf, 2015).

In Sri Lanka, government budgets are limited and use of funds must be maximum utilized and balanced against disease prevention management for sustainable FMD control program. Like in other developing countries poor awareness and knowledge of animal diseases is main constraint for prevention and control of FMD. The results of this study revealed motivate the farmers to increase better participation in regular vaccination to increase vaccination coverage is vital for maintain the herd immunity. To increase the farmers, the livestock training program particularly consider on disease identification and hygiene management should be conducted. Furthermore, some farmers seeking help from a veterinarian was often their last option should all self-treatment intervention fail. Small holder farmers in India only seeking veterinary assistance when a disease has reached an advance stage and this good evidence for the own practices to control disease. (Kumar and Gupta, 2018). Farmer-veterinarian communication is vital for improving the knowledge and attitudes towards animal disease to promote immediate reporting of FMD for curtail the spread of disease in traditional farming system. Successful livestock disease control programs depend not only on technical and economic feasibilities but also on the motivation of the stakeholders, especially active community involvement is required (Roeder and Taylor, 2007). Providing information about the risk of the disease to farmers to enhance the desired behavior with regard to FMD control.

CHAPTER 7

Conclusion

Efforts need to be intensified to control and eradicate FMD in Sri Lanka. Success stories are available with respect to control and the eventual eradication of FMD in South America and European countries. Successful control and eradication of the disease in these countries following vaccination program. Other countries to follow the progressive control path way of the disease Sporadic FMD outbreaks have continued among traditional farming system. It was revealed that the policies for sustainable control of FMD adopted in other countries need to modified to suit the condition in Sri Lanka. Socio-economic issues make create complicate the implementation of a control program. FMD has been a serious threat to cattle industry in Sri Lanka. The disease is endemic in the country particularly in the eastern province. Therefore, FMD has been ranked as the highest priority cattle disease for control and eradication.

It was found that farmers' knowledge, attitudes and practices (KAP) towards FMD was poor and lead to risk farming behavior such as poor knowledge on FMD transmission, vaccination and biosecurity practices; this clearly showed asymmetry information among farmers in this study population. Study on KAPs of farmers revealed helpful information on FMD, which could be used to improve the future implementation of methods to control FMD.

Farmers' vaccination participation and vaccination coverage should be increased in mass vaccination to prevent outbreaks. Make sure the regular interval of systematic biannual schedule of vaccine program lead to improve vaccine coverage. After vaccination, veterinary authority make arrangement to provide the FMD vaccination record card to farm owner to motivate for regular FMD vaccine.

To encourage the free FMD vaccination, farmers need to educate on FMD impact and its' control by organizing frequent training program in relevant veterinary division. Public awareness programs would be useful in educating farmers is an important intervention on the risk of FMD, hygiene management, isolation of FMD infected animal, animal movement restriction during FMD outbreak and recommended vaccination practices. Improved understanding of epidemiology of FMD can facilitate to identify risk-based control measures that can be implemented to reduce disease impact.

Immediate reporting of FMD to animal health authority to be key factor in detecting disease incursion and implement necessary action to curtail further spread to other regions. Strict enforce and farmers motivation for their early reporting and engaging in regular information sharing and innovative reporting to be most cost-effective in detecting disease and lowering introduction risk.

Farmers' knowledge and embedded indigenous behavior is crucial in animal diseases control. Changing farmer behavior should be enhance to adopt effective way of disease control. Therefore, it should be essentially considered in disease control policy planning.

References

Abeygunawardena, H. A., Rathnayaka, D. and Jayathilaka, W. M. A. P. (1997) Characteristics of cattle farming systems in Sri Lanka. *Journal of National Science Foundation,* Sri Lanka, 25(1): 25-38.

Abeyratne, S.A.E., Amarasekera, S.S.C., Ranaweera, L.T., Salpadoru, T.B., Thilakarathne, S.M.N.K., Knowles, N.J., Wadsworth, J., Puvanendiran, S., Kothalawala, H., Jayathilake, B.K. and Wijithasiri, H.A. (2018) The phylogenetic analysis of VP1 genomic region in foot and mouth disease virus serotype O isolates in Sri Lanka reveals the existence of'Srl-97', a newly named endemic lineage. *PloS one*, 13(3): p.e0194077.

Ajzen, I. (1991) The theory of planned behaviour. Organizational Behaviour and Human Decision Processes, 50 (2): 179-211.

Al-Shamahy, H.A., Whitty, C.J.M. and Wright, S.G. (2000) Risk factors for human brucellosis in Yemen: a case control study. *Epidemiology & Infection*, 125(2): 309-313.

Alexandersen, S., Zhang, Z., Donaldson, A.I. and Garland, A.J.M. (2003) The pathogenesis and diagnosis of foot and mouth disease. *Journal of comparative pathology*, 129(1): 1-36.

Allport, G.W. (1935) Attitudes Murchison, C. ed. Handbook of social psychology Vol. 2 Clark University Press, Worcester, Mass.

Anderson, R.M. and May, R.M. (1991) Infectious diseases of humans: dynamics and control. Oxford university press.

Arif, S., Thomson, P.C., Hernandez-Jover, M., McGill, D.M., Warriach, H.M. and Heller, J. (2017) Knowledge, attitudes and practices (KAP) relating to brucellosis in smallholder dairy farmers in two provinces in Pakistan. *PloS one*, 12(3): p.e0173365.

Audarya, S.D. (2020) Foot and Mouth Disease in India: Past, Present and Future Outlook, A Review. *Some RNA Viruses*.

Ayalew, W. and Mulatu, W. (2005) Farmers' practices in the management of Trypanosomosis in the Ghibe Valley, Southwestern Ethiopia. *ESAP Proc*, (9): 59.

Baazizi, R., Mimoune, N., M'Hamed El Mokhefi, M.R., Chahed, A. and Hussain, T. (2019) Knowledge and behavior of cattle and sheep owners and herders regarding foot-and-mouth disease in Northern Algeria. *Veterinary world*, 12(8): 1285.

Bachanek-Bankowska, K., Di Nardo, A., Wadsworth, J., Mioulet, V., Pezzoni, G., Grazioli, S., Brocchi, E., Kafle, S.C., Hettiarachchi, R., Kumarawadu, P.L. and Eldaghayes, I.M. (2018) Reconstructing the evolutionary history of pandemic foot-and-mouth disease viruses: the impact of recombination within the emerging O/ME-SA/Ind-2001 lineage. *Scientific reports*, *8*(1):1-11.

Bae, S.C., Min, J.H. and Jung, S. (2011) Trading behavior, performance, and stock preference of foreigners, local institutions, and individual investors: Evidence from the Korean stock market. *Asia-Pacific Journal of Financial Studies*, 40(2): 199-239.

Bandara, B.H.W.M.U.S. (2000) The current status of smallholder dairy systems in Sri Lanka. Smallholder dairy production and marketing—Opportunities and constraints, 22.

Barkallah, M., Gharbi, Y., Zormati, S., Karkouch, N., Mallek, Z., Gautier, M., Gdoura, R. and Fendri, I. (2017) A mixed methods study of ruminant brucellosis in central-eastern Tunisia, *Tropical Animal Health and production*, 49 (1): 39-45.

Barrett, J.R. (2001) Livestock farming: eating up the environment? *Environmental Health Perspectives*, 109(7): A312-A317.

Basagoudanavar, S.H. and Hosamani, M. (2013) Trans-boundary diseases of animals: mounting concerns. *Vet Scan Online Veterinary Medical Journal*, 7(2): 119-119.

Bayissa, B., Ayelet, G., Kyule, M., Jibril, Y. and Gelaye, E. (2011) Study on seroprevalence, risk factors, and economic impact of foot-and-mouth disease in Borena pastoral and agro-pastoral system, southern Ethiopia. *Tropical animal health and production*, 43(4): 759-766.

Biswal, J.K., Sanyal, A., Rodriguez, L.L., Subramaniam, S., Arzt, J., Sharma, G.K., Hammond, J.M., Parida, S., Mohapatra, J.K., Mathapati, B.S. and Dash, B.B. (2012) Foot and mouth disease: Global status and Indian perspective. *Indian Journal of Animal science*, 82(2):109-131.

Blacksell, S.D., Siengsanan-Lamont, J., Kamolsiripichaiporn, S., Gleeson, L.J. and Windsor, P.A. (2019) A history of FMD research and control programmes in Southeast Asia: lessons from the past informing the future. *Epidemiology & Infection*, *147*.

Boateng, A., Asongu, S., Akamavi, R. and Tchamyou, V. (2018) Information asymmetry and market power in the African banking industry. *Journal of Multinational Financial Management*, 44: 69-83.

Brennan, M.L. and Christley, R.M. (2013) Cattle producers' perceptions of biosecurity. *BMC veterinary research*, 9(1): 1-8.

Brito, B.P., Rodriguez, L.L., Hammond, J.M., Pinto, J. and Perez, A.M. (2017) Review of the global distribution of foot and mouth disease virus from 2007 to 2014. *Transboundary and emerging diseases*, 64(2): 316-332.

Bronsvoort, B.M.C., Radford, A.D., Tanya, V.N., Nfon, C., Kitching, R.P. and Morgan, K.L. (2004) Molecular epidemiology of foot and mouth disease viruses in the Adamawa province of Cameroon. *Journal of Clinical Microbiology*, 42(5): 2186-2196.

Brown, A.G. (2003) The livestock revolution: a pathway from poverty? Record of a conference conducted by the ATSE Crawford Fund, Parliament House, Canberra, Australia.

Bruinsma, J. (2003) World agriculture: towards 2015/2030: an FAO perspective. Earthscan publication, London, UK.

Buetre, B., Wicks, S. and Kruger, H. (2013) Potential socio-economic impacts of an outbreak of foot and mouth disease in Australia. Australian Bureau of Agricultural and Resources Economics and Sciences, *Research Report* 13.11. Canberra, ACT.

Bulman, G. and Terrazas, M.I. (1976) Effect of foot and mouth disease on milk production at a model farm in Cochabamba, Bolivia. [Spanish] Consideraciones sobre el efecto de la fiebre aftosa en la produccion lactea de un tambo modelo en Cochabamba, Bolivia. *Revista de Medicina Veterinaria, Argentina*, 57(1): 1-2.

Bulmer, M. and Warwick, D.P. (1993) Social research in developing countries: Surveys and censuses in the Third World. Psychology Press.

Burton, R.J. (2004) Reconceptualising the 'behavioural approach' in agricultural studies: a socio-psychological perspective. *Journal of Rural studies*, 20(3): 359-371.

Byarugaba, D.K., Khaitsa, M.L. and Opuda Asibo, J. (1998) Bovine Mastitis in North Kyadondo County of Kampala District. *Uganda Veterinary Journal*, 4: 139-146.

Cameron, A.C. and Trivedi, P.K. (2010) Microeconometrics using data, Volume 2. College station, TX: Stata press.

Cappai, S., Rolesu, S., Coccollone, A., Laddomada, A. and Loi, F. (2018) Evaluation of biological and socio-economic factors related to persistence of African swine fever in Sardinia. *Preventive Veterinary Medicine*, 152: 1-11.

Carter, M.R. and Barrett, C.B. (2006) The economics of poverty traps and persistent poverty: An asset-based approach. *The Journal of Development Studies*, 42(2): 178-199.

Caselli, F. (2005) Accounting for cross-country income differences. *Handbook of economic growth*, 1: 679-741.

Catley, A., Burns, J., Abebe, D. and Suji, O. (2008) Participatory impact assessment: a guide for practitioners. Tufts university.

Cediel, N., Conte, V., Tomassone, L., Tiberti, D., Guiso, P., Romero, J., Villamil, L.C. and De Meneghi, D. (2012) Risk perception about zoonoses in immigrants and Italian workers in Northwestern Italy. *Revista de Saúde Pública*, 46: 850-857.

Chymis, A.G., James Jr, H.S., Konduru, S., Pierce, V.L. and Larson, R.L. (2007) Asymmetric information in cattle auctions: the problem of revaccinations. *Agricultural Economics*, 36(1): 79-88.

Cottam, E.M., Haydon, D.T., Paton, D.J., Gloster, J., Wilesmith, J.W., Ferris, N.P., Hutchings, G.H. and King, D.P. (2006) Molecular epidemiology of the foot and mouth disease virus outbreak in the United Kingdom in 2001. *Journal of Virology*, 80(22): 11274-11282.

Cranfield, A.L., Hertel, T.W., Eales, J.S. and Preckel, P.V. (1998) Changes in the structure of global food demand. *American Journal of Agricultural Economics*, 80(5): 1042-1050.

Crowe, C. and Oxtoby, T. (2019) Strengthening the vet-farmer relationship. *In Practice*, 41(6): 275-277.

DAPH (2009) Estimation of cost of production of milk in different agro-climatic zones of Sri Lanka. Department of Animal Production and Health, Peradeniya Sri Lanka. http://daph.gov.lk

DAPH (2010) Annual report, Department of Animal Production and Health., Peradeniya, Sri Lanka. http://daph.gov.lk

DAPH (2014) Annual report, Department of Animal Production and Health., Peradeniya, Sri Lanka. http://daph.gov.lk

DAPH (2016) Annual report, Department of Animal Production and Health., Peradeniya, Sri Lanka. http://daph.gov.lk

DAPH (2019) Annual report, Department of Animal Production and Health., Peradeniya, Sri Lanka. http://daph.gov.lk

DCS (2012) Report on census of population and housing, Department of Census and Statistics, Sri Lanka, Accessed on: http:// www.statistics.gov.lk / PopHouSat/ CPH 2011/Pages/Activities/Reports/District/Ampara/A3.pdf

DCS (2018) Department of Census and Statistics, Agriculture and environmental statistic division., Colombo, Sri Lanka, in http://www.statistics.gov.lkagriculture/livestock/livestock population subnational. htmt.

DCS (2020) Department of Census and Statistics, Colombo, Sri Lanka, in http: //www. statistics.gov.lk /abstarct2020/ preface.

Damodar, G. (2015) Econometrics. 2nd Ed. Palgrave, 170–227.

Davis, B., Winters, P., Carletto, C., Covarrubias, K., Quiñones, E.J., Zezza, A., Stamoulis, K., Bonomi, G. and Di Giuseppe, S. (2008) Rural income generating activities: A cross country comparison. background paper for the *World Development Report*.

De Jong, T. and Ferguson-Hessler, M.G. (1996) Types and qualities of knowledge. *Educational psychologist*, 31(2): 105-113.

Delgado, A.H., Norby, B., Scott, H.M., Dean, W., McIntosh, W.A. and Bush, E., 2014. Distribution of cow-calf producers' beliefs regarding gathering and holding their cattle and observing animal movement restrictions during an outbreak of foot and mouth disease. *Preventive veterinary medicine*, 117(3-4): 518-532.

Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S. and Courbois, C. (1999) Livestock to 2020. The next food revolution, Food, Agriculture and Environment discussion paper 28. IFPRI, International Food Policy Research Institute (IFPRI), Washington DC, USA, 72.

Delgado, C.L. (2003) Rising consumption of meat and milk in developing countries has created a new food revolution. *The Journal of nutrition*, 133(11): 3907S-3910S.

Dernburg, A. R., Fabre, J., Philippe, S., Sulpice, P. and Calavas, D. (2007) A study of the knowledge, attitudes, and behaviors of French dairy farmers toward the farm register, *Journal of Dairy Science*, 90(4): 1767-1774.

Di Nardo, A., Knowles, N.J. and Paton, D.J. (2011) Combining livestock trade patterns with phylogenetics to help understand the spread of foot and mouth disease in sub-Saharan Africa, the Middle East and Southeast Asia. *Revue Scientifique et Technique-OIE*, *30*(1): 63-85.

Dissanayake, D.M.R.B., Stephen, C., Daniel, S., and Abeynayake, P. (2012) Gap assessment of animal health legislation in Sri Lanka for emerging infectious disease preparedness. *Outlook on Agriculture*, volume 41(3): 203-208.

Domenech, J., Lubroth, J., Eddi, C., Martin, V. and Roger, F. (2006) Regional and international approaches on prevention and control of animal transboundary and emerging diseases. *Annals of the New York Academy of Sciences*, 1081(1): 90-107.

Donaldson, A.I. (1987) Foot and mouth disease the principal feature. *Irish Veterinary Journal,* 41: 325-327.

Dorward, A., Anderson, S. and Paz, R. (2005) A guide to indicators and methods for assessing the contribution of livestock keeping to livelihoods of the poor.

Dukpa, K., Robertson, I.D., Edwards, J.R., Ellis, T.M., Tshering, P., Rinzin, K. and Dahal, N. (2011) Risk factors for foot-and-mouth disease in sedentary livestock herds in selected villages in four regions of Bhutan. *New Zealand Veterinary Journal*, 59(2): 51-58.

EB (2012) Veterinary epidemiological bulletin, Department of Animal Production and Health, Peradeniya, Sri Lanka.

EB (2013) Veterinary epidemiological bulletin, Department of Animal Production and Health, Peradeniya, Sri Lanka.

EP (2019) Statistical information, livestock, Eastern Province, Livestock, Department of Animal Production and Health, Trincomale

Ellis, P.R. and James, A.D. (1976) Foot and Mouth Disease: India. In *Inter-national Symposia on Veterinary Epidemiology and Economics proceedings, ISVEE* (1): 118-122.

Ellis, P.R. and Putt, S.N.H. (1981) The Epidemiological and Economic Implications of the Foot and Mouth Disease Vaccination Programme in Kenya. Pan Livestock Services. *Reading,* UK.

Ellis-Iversen, J., Cook, A.J., Watson, E., Nielen, M., Larkin, L., Wooldridge, M. and Hogeveen, H. (2010) Perceptions, circumstances and motivators that influence implementation of zoonotic control programs on cattle farms. *Preventive veterinary medicine*, 93(4): 276-285.

EuFMD (2020) FAST Reports, Foot-and-mouth And Similar Transboundary animal diseases, European Commission for the control of Foot and Mouth Disease, July-September, Quarterly report.

FAO (2002) Improved animal health for poverty reduction and sustainable livelihoods, animal production and health; paper n' 153, chapter 1.

FAO (2012) The Progressive Control Pathway for FMD control (PCP-FMD). Principles, Stages description Sans standard, Rome.

FAO (2018a) The progressive control pathway for FMD control (PCP-FMD). fao.org / eufmd global-situation / pcp-fmd / en/pdf

FAO (2018b) The Global Foot and Mouth Disease control strategy. fao.org / ag / againfo/ programmes/en / empres / disease_ fmd. asp, pdf

FAO/OIE (2004) Joint FAO/OIE Initiative. The global frame work for the progressive control of transboundary animal diseases (GF-TADs).

FAO/OIE (2016) Global framework for the progressive control of transboundary animal diseases, The 3rd regional roadmap meeting on PCP-FMD for SAARC member states, 14-16 December 2016, Colombo, Sri Lanka.

FAOSTAT (2010) Food and Agriculture Organization of the United Nations, Statistical database, Rome, Italy.

FAOSTAT (2011) Food and Agriculture Organization of the United Nations, Statistical database, Rome, Italy.

Fernando W.W.H.S (1969a) Foot and mouth disease in Ceylon. Part 1 history, epizootiology and economic losses. *Ceylon Veterinary journal*, (XVII)3, 43-58

Fernando, W.W.H.S (1969b) Foot and mouth disease in Ceylon. II. Serological types of the virus present in Ceylon. *The Ceylon veterinary journal*.

Ferrari, G., Paton, D., Duffy, S., Bartels, C., Knight-Jones, T., Metwally, S. and Münstermann, S. (2016) Foot and mouth disease vaccination and post-vaccination monitoring. FAO/OIE.

Forman, S., Le Gall, F., Belton, D., Evans, B., François, J.L., Murray, G., Sheesley, D., Vandersmissen, A. and Yoshimura, S. (2009) Moving towards the global control of foot and mouth disease: an opportunity for donors. *Revue scientifique et technique*, (OIE) *28*(3): 883.

Foster, A.D. and Rosenzweig, M.R. (2010) Microeconomics of technology adoption. *Annu. Rev. Econ.*, 2(1): 395-424.

Gadd, M.E. (2012) Barriers, the beef industry and unnatural selection: a review of the impact of veterinary fencing on mammals in Southern Africa. *Fencing for conservation*, Springer, New York, USA, p153-186.

Gakuya, D.W., Mulei, C.M. and Wekesa, S.B. (2011) Use of ethnoveterinary remedies in the management of foot and mouth disease lesions in a dairy herd. *African Journal of traditional, complementary and alternative medicines*, 8(2).

Gamage, C.D., Koizumi, N., Perera, A.C., Muto, M., Nwafor-Okoli, C., Ranasinghe, S., Kularatne, S.A.M., Rajapakse, R.P.V.J., Kanda, K., Lee, R.B. and Obayashi, Y. (2012) Carrier Status of Leptospirosis Among Cattle in Sri Lanka: A Zoonotic Threat to Public Health. *Transboundary and emerging diseases*, 61(1): 91-96.

Ghotge, N.S., Ramdas, S.R., Ashalata, S., Mathur, N.P., Broome, V.G. and Rao, M.S. (2002) A social approach to the validation of traditional veterinary remedies–the ANTHRA Project. *Tropical Animal Health and Production*, 34(2): 121-143.

Gleeson, L.J. (2002) A review of the status of foot and mouth disease in South-East Asia and approaches to control and eradication. *Revue scientifique et technique-Office international des épizooties*, 21(3): 465-472.

Goswami, A. and Sagar, R. L. (1996) Development of cognitive learning scale to test the knowledge of livestock owners about vaccination against contagious diseases. *Journal Veterinary Animal Science,* (27): 32-37.

Grace, D., Jost, C., MacGregor-Skinner, G.J. and Mariner, J.C. (2008) Participation of small farmers in animal health programs.

Grubman, M.J. and Baxt, B. (2004) Foot and mouth disease. *Clinical microbiology reviews*, 17(2): 465-493.

Gunarathne, A., Kubota, S., Kumarawadu, P., Karunagoda, K. and Kono, H. (2016) Is hiding foot and mouth disease sensitive behavior for farmers? A survey study in Sri Lanka. *Asian-Australasian journal of animal sciences*, 29(2): 280.

Gunasekera, I. and Fernando, W.W.H.S. (1980) Introduction and spread of foot and mouth disease virus type C in Sri Lanka. *Ceylon Veterinary Journal*, 51-54.

Hall, J. and Wapenaar, W. (2012) Opinions and practices of veterinarians and dairy farmers towards herd health management in the UK. *Veterinary Record*, 170(17): 441-441.

Hamond, J. (2011) FMD Vaccine: Practical Applications from an International Perspective-FMDV Vaccine to Live. An event organised by NFUS, Moredun and Scottish Government, 15 March 2011, p1292-1298.

Hegazy, Y., Elmonir, W., Abdel-Hamid, N.H. and Elbauomy, E.M. (2016) Seroprevalence and "Knowledge, Attitudes and Practices" (KAPs) survey of endemic ovine brucellosis in Egypt. *Acta Veterinaria Scandinavica*, 58(1): 1-7.

Hennessy, D.A. (2007) Behavioral incentives, equilibrium endemic disease, and health management policy for farmed animals. *American Journal of Agricultural Economics*, 89(3): 698-711.

Hennessy, D.A. and Wolf, C.A. (2015) Asymmetric information, externalities and incentives in animal disease prevention and control. *Journal of Agricultural Economics*, 69(1): 226-242.

Herrero, M., Thornton, P.K., Gerber, P. and Reid, R.S. (2009) Livestock, livelihoods and the environment: understanding the trade-offs. *Current Opinion in Environmental Sustainability*, 1(2): 111-120.

Hidano, A., Carpenter, T.E., Gates, M.C., Stevenson, M.A. and Enticott, G. (2017a) Big data" and "small data": towards a better understanding of disease data by modelling human behaviour. In 3rd International Conference on Animal Health Surveillance (Rotorua), Available online at: http://www. animalhealthsurveillance. org/programme/programme-and-presentations.

Hidano, A., Enticott, G., Christley, R.M. and Gates, M.C. (2018) Modeling dynamic human behavioral changes in animal disease models: challenges and opportunities for addressing bias. *Frontiers in Veterinary Science*, (5): 137.

Hidano, A., Gates, M.C., Carpenter, T.E. and Enticott, G. (2017b) Farmer decision-making around livestock trading practices: the multifactorial roles of stock agents. In Inaugural Meeting of ISESSAH, Aviemore: *International Society for Economics and Social Sciences of Animal Health,* (91).

Higuchi, K (n.d)b KH Codern3 Reference manual. URL: https : // khcoder.net / en manual_ en_ v3. pdf

Higuchi, K. (2017) A Two-Step Approach to quantitative content analysis: KH Coder tutorial using Anne of Green Gables (Part 2). *Ritsumeikan social sciences review*, 53(1): 137-147.

Higuchi, K. (n.d)a KH Coder index page. URL: https: //khcoder.net/en/

Hogg, M.A., and Vaughan, G.M. (2005) Social Psychology, 4th Edition, Prentice Hall, The University of California.

Huttner, K., Leidl, K., Pfeiffer, D.U., Jere, F.B.D. and Kasambara, D. (2001) Farm and personal characteristics of the clientele of a community-based animal health service programme in northern Malawi. *Tropical Animal Health and Production*, 33(3): 201-218.

ILRI (2008) ILRI Annual Report 2007: Markets that work – making a living from livestock International Livestock Research Institute (ILRI), Nairobi, Kenya

Ibrahim, M.N., Staal, S.J., Daniel, S.L.A. and Thorpe, W.R. (1999a) Appraisal of the Sri Lanka Dairy Sector Volume 1: Main Report.

Ibrahim, M.N., Staal, S.J., Daniel, S.L.A. and Thorpe, W.R. (1999b) Appraisal of the Sri Lanka dairy sector volume 2: Main report.

Jaccard, P. (1912) The distribution of the flora in the alpine zone. 1. *New phytologist*, 11(2): 37-50.

Jamal, S.M. and Belsham, G.J. (2013) Foot and mouth disease: past, present and future. *Veterinary research*, 44(1): 1-14.

James, A.D. and Rushton, J. (2002) The economics of foot and mouth disease. *Revue scientifique et technique, office international des epizooties* (OIE) 21(3): 637-644.

Jansen, J. and Lam, T.J. (2012) The role of communication in improving udder health. *Veterinary Clinics: Food Animal Practice*, 28(2): 363-379.

Jansen, J., Van Schaik, G., Renes, R.J. and Lam, T.J.G.M. (2010) The effect of a national mastitis control program on the attitudes, knowledge, and behavior of farmers in the Netherlands. *Journal of Dairy Science*, 93(12): 5737-5747.

Jansen, J.B.H.P., Van den Borne, B.H.P., Renes, R.J., Van Schaik, G., Lam, T.J.G.M. and Leeuwis, C. (2009) Explaining mastitis incidence in Dutch dairy farming: the influence of farmers' attitudes and behaviour. *Preventive veterinary medicine*, 92(3): 210-223.

Janz, N.K. and Becker, M.H. (1984) The health belief model: A decade later. *Health education quarterly*, *11*(1): 1-47.

Jemberu, W.T., Mourits, M.C.M. and Hogeveen, H. (2015) Farmers' intentions to implement foot and mouth disease control measures in Ethiopia. *PloS one,* 10(9): p.e 0138363.

Kamel, M., El-Sayed, A. and Vazquez, H.C. (2019) Foot and mouth disease vaccines: recent updates and future perspectives. *Archives of virology*, 164(6): 1501-1513.

Khounsy, S., Conlan, J.V., Gleeson, L.J., Westbury, H.A., Colling, A., Paton, D.J., Knowles, N.J., Ferris, N.P. and Blacksell, S.D. (2008) Foot and mouth disease in the Lao People's Democratic Republic: I. A review of recent outbreaks and lessons from control programmes. *Scientific and Technical Review. Office International des Epizooties*, 27(3): 839-849.

Khoury, G. (2011) Extension programmes dedicated to the activities of the veterinary sciences, conference, OIE.

Kilian, L. (2012) Global Challenges in Animal Diseases. *IAEA Bulletin,* Division of public information, 53(3): 20.

Kitching, R.P. (2002) Clinical variation in foot and mouth disease: cattle. *Revue scientifique et technique-Office international des epizooties*, 21(3): 499-502.

Knight-Jones, T.J.D. and Rushton, J. (2013) The economic impacts of foot and mouth disease–What are they, how big are they and where do they occur? *Preventive veterinary medicine*, 112(3-4): 161-173.

Knowles, N.J. and Samuel, A.R. (2003) Molecular epidemiology of foot and mouth disease virus. *Virus research*, 91(1): 65-80.

Knowles, N.J., Samuel, A.R., Davies, P.R., Midgley, R.J. and Valarcher, J.F. (2005) Pandemic strain of foot and mouth disease virus serotype O. *Emerging infectious diseases*, 11(12): 1887.

Kodituwakku, S.N. (2000) Diagnosis and control of foot and mouth disease in Sri Lanka using ELISA- based technologies. inis.iaea.org, p123-129.

Kothalawala, K.A.C.H.A. (2011) Milk production under different management systems in Sri

Lanka an economic perspective. *Sri Lanka Veterinary Journal,* 58(B): 29.

Kristensen, E. and Jakobsen, E.B. (2011) Challenging the myth of the irrational dairy farmer; understanding decision-making related to herd health. *New Zealand Veterinary Journal*, 59(1): 1-7.

Kumar, V. and Gupta, J. (2018) Prevailing practices in the use of antibiotics by dairy farmers in Eastern Haryana region of India, *Veterinary World*, 11(3): 274-280.

Kumaraswamy, S. (1971) The significance of brucellosis in Ceylon. *Ceylon Veterinary Journal,* XIX (4): 119-123.

LSB (2017) Livestock Statistical Bulletin, Department pf Animal Production and Health, Peradeniya, Sri Lanka.

LSB (2019) Livestock Statistical Bulletin, Department pf Animal Production and Health, Peradeniya, Sri Lanka.

Laffont, J.J and Martimort, D. (2001) the theory of incentives i: the principal-agent model, Accessbile at file:///C:/Users/Hp/Downloads/incentives%20(1).pdf

Launiala, A. (2009) How much can a KAP survey tell us about people's knowledge, attitudes and practices? Some observations from medical anthropology research on malaria in pregnancy in Malawi. *Anthropology Matters*, 11(1).

Lebowitz, A., Kotani, K., Matsuyama, Y. and Matsumura, M. (2020) Using text mining to analyze reflective essays from Japanese medical students after rural community placement. *BMC medical education*, 20(1): 1-7.

León, E.A., Perez, A.M., Stevenson, M.A., Robiolo, B., Mattion, N., Seki, C., La Torre, J., Torres, A., Cosentino, B. and Duffy, S.J. (2014) Effectiveness of systematic foot and mouth disease mass vaccination campaigns in Argentina. *Rev Sci Tech*, 33: 917-926.

Lindahl, E., Sattorov, N., Boqvist, S. and Magnusson, U. (2015) A study of knowledge, attitudes and practices relating to brucellosis among small-scale dairy farmers in an urban and peri-urban area of Tajikistan. *PloS one*, 10(2): p.e0117318.

MMDE (n.d) Sri Lanka climate profile climate change secretariat, Ministry of Mahaweli development and environment Sri Lanka, Accessible at http:// www.climatechange.lk/ climate profile.html.

Mahmoud, M.A.E., Ghazy, A.A. and Shaapan, R.M. (2019) Diagnosis and control of foot and mouth disease (FMD) in dairy small ruminants; sheep and goats. *International Journal of Dairy Science*, 14: 45-52.

Makita, K. (2021) Comment on behavioral differences for animal infectious disease control based on farmers' background – Case study of FMD in Eastern Province, Sri Lanka. In Japanese *Journal of Agricultural Development Studies*, 32(1): 18-20.

Mangal, A.K. (2015) Traditional knowledge in veterinary medicine: A case study of Gorakhpur district, Uttar Pradesh (India). *International Journal of Advanced Research*, 3(1): 127-143.

Mankad, A. (2016) Psychological influences on biosecurity control and farmer decision-making. A review. *Agronomy for sustainable development*, *36*(2): 1-14.

Mansley, L.M., Donaldson, A.I., Thrusfield, M.V. and Honhold, N. (2011) Destructive tension: mathematics versus experience-the progress and control of the 2001 foot and mouth disease epidemic in Great Britain. *Revue Scientifique et Technique-OIE*, 30(2): 483-498.

Martimort, D. and Laffont, J.J. (2002) The theory of incentives: the principal-agent model. Princeton University Press.

Martin, S. W., Dietrich, R. A., Genho, P., Heuschle, W. P., Jones, R. L. and Koller, M. (1994) Epidemiologic/Economic Tuberculosis Studies and Bioeconomic Research considerations. In N. A. press, ed. Livestock Disease Eradication: Evaluation of the Cooperative State-Federal Bovine Tuberculosis Eradication Program.

Mellon-Bedi, S., Descheemaeker, K., Hundie-Kotu, B., Frimpong, S. and Groot, J.C.J. (2020) Motivational factors influencing farming practices in northern Ghana. *NJAS-Wageningen Journal of Life Sciences*, 92: 100326.

Millar, J. and Photakoun, V. (2008) Livestock development and poverty alleviation: Revolution or evolution for upland livelihoods in Lao PDR? *International journal of agricultural sustainability*, 6(1): 89-102.

Miller, G.Y., Bartlett, P.C., Lance, S.E., Anderson, J. and Heider, L.E. (1993) Costs of clinical mastitis and mastitis prevention in dairy herds. *Journal of the American Veterinary Medical Association*, 202(8): 1230-1236.

Moran, J.B. (2009) Key performance indicators to diagnose poor farm performance and profitability of smallholder dairy farmers in Asia. *Asian-Australasian Journal of Animal Sciences*, 22(12): 1709-1717.

Mort, M., Convery, I., Baxter, J. and Bailey, C. (2005) Psychosocial effects of the 2001 UK foot and mouth disease epidemic in a rural population: qualitative diary-based study. *Bmj*, 331(7527): 1234.

Motta, P., Graeme G., Mark H., Tsviatko A., Abdulnaci B., Ilektra A.F. and Keith S. (2019) A framework for reviewing livestock disease reporting systems in high-risk areas: assessing performance and perceptions towards foot and mouth disease reporting in the Thrace region of Greece, Bulgaria and Turkey. *Transboundary and emerging diseases*, 66(3): 1268-1279.

Mrsic, S.P. (2017) Market failures of organic agriculture and information asymmetry. *Economic and Business*, 38-42.

Musallam, I.I., Abo-Shehada, M.N. and Guitian, J. (2015) Knowledge, attitudes, and practices associated with brucellosis in livestock owners in Jordan. *The American Journal of Tropical Medicine and Hygiene*, 93(6): 1148-1155.

Nakano, Y., Tsusaka, T.W., Aida, T. and Pede, V.O. (2018) Is farmer-to-farmer extension effective? The impact of training on technology adoption and rice farming productivity in Tanzania, *World Development*, 105: 336-351.

Nampanya, S., Khounsy, S., Abila, R., Young, J. R., Bush, R. D. and Windsor, P.A. (2016) Financial impacts of foot-and-mouth disease at village and national levels in Lao PDR. *Transboundary and Emergency Disease*, 63 (5): 403-411.

Nampanya, S., Suon, S., Rast, L. and Windsor, P.A. (2012) Improvement in smallholder farmer knowledge of cattle production, health and biosecurity in southern Cambodia between 2008 and 2010. *Transboundary and emerging diseases*, 59(2): 117-127.

Niraj, K., Fisseha, K.K., Shishay, N. and Hagos, Y. (2014) Welfare assessment of working donkeys in Mekelle city, Ethiopia. *Global Veterinaria*, 12(3): 314-319.

Niwattanakul, S., Singthongchai, J., Naenudorn, E. and Wanapu, S. (2013) Using of Jaccard coefficient for keywords similarity. In *Proceedings of the international multiconference of engineers and computer scientists*, 1(6): 380-384.

Nokes, D.J. and Anderson, R.M. (1992) Mathematical models of infectious agent transmission and the impact of mass vaccination. *Rev Med Microbiol*, 3: 187-95.

Nyaguthii, D.M., Armson, B., Kitala, P.M., Sanz-Bernardo, B., Di Nardo, A. and Lyons, N.A. (2019) Knowledge and risk factors for foot and mouth disease among small-scale dairy farmers in an endemic setting. *Veterinary research*, *50*(1): 1-12.

Nye, C., Watson, T., Kubasiewicz, L.M., Raw, Z. and Burden, F. (2021) 'Don't Put the Cart before the Mule!' Challenging Assumptions Regarding Health-Related Treatment Practices of Working Equid Owners in Northern India. *Animals*, 11(5): 1307.

OIE (2004) Office for International des Epizootics In: Manual of diagnostic Tests for foot and mouth disease. Bull. *Office International des Epizooties*, 77: 1381

OIE (2007) SEAFMD: a road map for foot and mouth disease freedom with vaccination by 2020 in South East Asia, Regional coordination unit, OIE Sub commission for foot and mouth disease in South East Asia, *Office International des Epizooties.*

OIE (2019) https://www.oie.int/en/animal-health-in-the-world/animal-diseases/Foot-and-mouth-disease.

OIE (2020) World Animal Health Organization Accessed on: https://www.oie.int/en/animal-health -in-the-world/official-disease-status/fmd/list-of-fmd-free-members/#c10686

OIE (2021) World Animal Health Organization, official disease status, Map of FMD official status, Accessed on: oie.int/en/disease/foot-and-mouth-disease/#ui-id-2

OIE/Iowa State University (2007), Disease card-foot and mouth diseases center for food security and public health, Ames, Iowa, USA. p1-6.

Oladele, O.I., Kolawole, A.E. and Antwi, M.A. (2013) Knowledge of biosecurity among livestock farmers along border villages of South Africa and Botswana. *Asian Journal of Animal and Veterinary Advances*, 8(7): 874-884.

Onono, J.O., Wieland, B. and Rushton, J. (2013) Constraints to cattle production in a semiarid pastoral system in Kenya. *Tropical animal health and production*, *45*(6): 1415-1422.

Osmani, A., Habib, I. and Robertson, I.D. (2021) Knowledge, Attitudes, and Practices (KAPs) of Farmers on Foot and Mouth Disease in Cattle in Baghlan Province, Afghanistan: A Descriptive Study. *Animals*, 11(8): 2188.

Otte, J. and Upton, M. (2005) Poverty and livestock agriculture, Pro-poor livestock policy initiative, A living from livestock, *Research report.*

Otte, M.J., Nugent, R. and McLeod, A. (2004) Transboundary animal diseases: Assessment of socio-economic impacts and institutional responses. Livestock policy discussion paper No. 9. *Food and Agriculture Organization (FAO)*, Rome, Italy.

Palmer, S., Fozdar, F. and Sully, M. (2009) The effect of trust on West Australian farmers' responses to infectious livestock diseases. *Sociologia Ruralis*, 49(4): 360-374.

Pannell, D.J. (2008) Public benefits, private benefits, and policy mechanism choice for land-use change for environmental benefits. *Land economics*, 84(2): 225-240.

Parida, S. (2009) Vaccination against foot and mouth disease virus: strategies and effectiveness, *Expert review of vaccines,* 8(3): 347-365.

Paton, D.J., Gubbins, S. and King, D.P. (2018) Understanding the transmission of foot and mouth disease virus at different scales. *Current opinion in virology*, 28: 85-91.

Paton, D.J., Sumption, K.J. and Charleston, B. (2009) Options for control of foot and mouth disease: knowledge, capability and policy. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1530): 2657-2667.

Paton, D.J., de Clercq, K., Greiner, M., Dekker, A., Brocchi, E., Bergmann, I., Sammin, D.J., Gubbins, S. and Parida, S. (2006) Application of non-structural protein antibody tests in substantiating freedom from foot and mouth disease virus infection after emergency vaccination of cattle. *Vaccine*, 24(42-43): 6503-6512.

Pattnaik, B., Subramaniam, S., Sanyal, A., Mohapatra, J.K., Dash, B.B., Ranjan, R. and Rout, M. (2012) Foot and mouth disease: global status and future road map for control and prevention in India. *Agricultural Research*, 1(2): 132-147.

Perera, B.M.A.O and Jayasuria, M.C.N (2008) The dairy industry in Sri Lanka: current status and future directions for a greater role in national development. *Journal of National Science Foundation,* Sri Lanka, 36: 115-126.

Perry, B. and Grace, D. (2009) The impacts of livestock diseases and their control on growth and development processes that are pro-poor. *Philosophical Transactions of the Royal Society B: Biological Science*s, 364(1530): 2643-2655.

Perry, B.D. and Randolph, T.F. (2003) The economics of foot and mouth disease, its control and its eradication. IN: Bodet, B. and Vicari, M. (eds), Foot and mouth disease control strategies. Elsevier SAS, Paris: p23-41.

Perry, B.D. and Rich, K.M. (2007) Poverty impacts of foot-and-mouth disease and the poverty reduction implications of its control. *Veterinary Record*, 160(7): 238-241.

Perry, B.D. and Sones, K.R. (2007) Global roadmap for improving the tools to control foot-and-mouth disease in endemic settings: report of a workshop held at Agra, India, 29 November-1 December 2006, and subsequent roadmap outputs. ILRI (International Livestock Research Institute) (aka ILCA and ILRAD), Nirobi.

Perry, B.D., Kalpravidh, W., Coleman, P.G., Horst, H.S., McDermott, J.J., Randolph, T.F. and Gleeson, L.J. (1999) The economic impact of foot and mouth disease and its control in South-East Asia: a preliminary assessment with special reference to Thailand. *Revue scientifique et technique (International Office of Epizootics - OIE)*, 18(2): 478-497.

Ranaweera, L.T., Wijesundara, W.W.M.U.K., Jayarathne, H.S.M., Knowles, N.J., Wadsworth, J., Gray, A., Adikari, A.M.J.B., Weebadde, C.K. and Sooriyapathirana, S.D.S.S. (2019) Transboundary movements of foot and mouth disease from India to Sri Lanka: A common pattern is shared by serotypes O and C. *PloS one*, 14(12): p.e0227126.

Ranaweera, N.F.C. (2008) Sri Lanka: Opportunities for dairy sector growth, Smallholder dairy development: Lessons learned in Asia. Food and Agriculture Organization, Regional Office for Asia and the Pacific, Bangkok.

Reed, M.S., Evely, A.C., Cundill, G., Fazey, I., Glass, J., Laing, A., Newig, J., Parrish, B., Prell, C., Raymond, C. and Stringer, L.C. (2010) What is social learning? *Ecology and society*, 15(4).

Rezvanfar, A. (2007) Communication and socio-personal factors influencing adoption of dairy farming technologies amongst livestock farmers, *Livestock Research for Rural Development*, 19 (3): 33.

Richens, I.F., Hobson-West, P., Brennan, M.L., Lowton, R., Kaler, J. and Wapenaar, W. (2015) Farmers' perception of the role of veterinary surgeons in vaccination strategies on British dairy farms. *Veterinary Record*, 177(18): 465-465.

Riley, M. (2008) Experts in their fields: Farmer - expert knowledges and environmentally friendly farming practices. *Environment and Planning,* 40(6): 1277-1293.

Ritter, C., Jansen, J., Roche, S., Kelton, D.F., Adams, C.L., Orsel, K., Erskine, R.J., Benedictus, G., Lam, T.J. and Barkema, H.W. (2017) Invited review: Determinants of farmers' adoption of management-based strategies for infectious disease prevention and control. *Journal of Dairy Science*, 100(5): 3329-3347.

Ritter, C., Jansen, J., Roth, K., Kastelic, J.P., Adams, C.L. and Barkema, H.W. (2016) Dairy farmers' perceptions toward the implementation of on-farm Johne's disease prevention and control strategies. *Journal of dairy science*, 99(11): 9114-9125.

Roeder, P.L. and Taylor, W.P. (2007) Mass vaccination and herd immunity: cattle and buffalo. *Revue scientifique et technique (International Office of Epizootics)*, 26(1): 253-263.

Romer, P.M. (1990) Endogenous technological change. *Journal of political Economy*, Part 2, 98(5): 71-102.

Rosegrant, M.W., Fernández, M.A.R.I.A., Sinha, A.N.U.S.H.R.E.E., Alder, J.A.C.K.I.E., Ahammad, H., Fraiture, C.D., Eickhout, B., Fonseca, J.O.R.G.E., Huang, J.I.K.U.N., Koyama, O.S.A.M.U. and Omezzine, A.M. (2009) Looking into the future for agriculture and AKST.

Rosenstock, I.M., Strecher, V.J. and Becker, M.H. (1988) Social learning theory and the health belief model. *Health education quarterly*, 15(2):175-183.

Rufael, T., Catley, A., Bogale, A., Sahle, M. and Shiferaw, Y. (2008) Foot and mouth disease in the Borana pastoral system, southern Ethiopia and implications for livelihoods and international trade. *Tropical animal health and production*, 40(1): 29-38.

Rushton, J. (2009) The economics of animal health and production. CAB International, Oxfordshire and Massachusetts, p193-197.

Rweyemamu, M., Roeder, P., Mackay, D., Sumption, K., Brownlie, J., Leforban, Y., Valarcher, J.F., Knowles, N.J. and Saraiva, V. (2008) Epidemiological patterns of foot-and-mouth disease worldwide. *Transboundary and emerging diseases*, 55(1): 57-72.

Saini, S. S., Sharma, J. K. and Kwatra., S.M. (1992) Assessment of some factors affecting the prevalence of foot and mouth disease among the traditionally managed animal population of Punjab state. Socio-economic and animal health-related interests. *Indian Journal of Animal Science*, 62 (1): 1-4.

Salloum, S.A., Al-Emran, M., Monem, A.A. and Shaalan, K. (2018) Using text mining techniques for extracting information from research articles. In *Intelligent natural language processing: Trends and Applications,* p373-397.

Samuel, A.R. and Knowles, N.J. (2001) Foot and mouth disease type O viruses exhibit genetically and geographically distinct evolutionary lineages (topotypes). *Journal of General Virology*, 82(3): 609-621.

Sangula, A.K., Siegismund, H.R., Belsham, G.J., Balinda, S.N., Masembe, C. and Muwanika, V.B. (2011) Low diversity of foot-and-mouth disease serotype C virus in Kenya: evidence for probable vaccine strain re-introductions in the field. *Epidemiology & Infection*, 139(2): 189-196.

Schemann, K., Firestone, S.M., Taylor, M.R., Toribio, J.A., Ward, M.P. and Dhand, N.K. (2012) Horse owners'/managers' perceptions about effectiveness of biosecurity measures based on their experiences during the 2007 equine influenza outbreak in Australia. *Preventive veterinary medicine*, 106(2): 97-107.

Schieg, M. (2008) Strategies for avoiding asymmetric information in construction project management. *Journal of Business Economics and Management*, 1:47-51.

Segundo, D. F., Montiel, N.A., Sturza, D.F., Perez-Martin, E., Hickman, D., Ramirez-Medina, E., Grubman, M.J. and de Los Santos, T. (2016) Combination of Adt-O1Manisa and Ad5-boIFNλ3 induces early protective immunity against foot and mouth disease in cattle. *Virology*, 499: 340-349.

Seré, C., Steinfeld, H. and Groenewold, J. (1996) World livestock production systems.: Current status, issues and trends. Food and Agriculture Organization Animal production and Health paper 127, Rome, Italy.

Shijan, I. and Matiul I. (2020) Evaluation of knowledge, attitude and practice (KAP) of farmers regarding organic farming. *Fundamental and Applied Agriculture*, 5(3): 393-403.

Shimodaira, H. and Fukuda, S. (2014) Popularization of Classical Economics: The text-mining Analysis of David Ricardo, James Mill, and Harriet Martineau. *Research Group of Economics and Management*.

Sieng, S., Patrick, I.W., Windsor, P.A., Walkden-Brown, S.W., Sar, C., Smith, R.G.B. and Kong, R. (2021) Knowledge, attitudes and practices of smallholder farmers on foot and mouth disease control in two Cambodian provinces. *Transboundary and Emerging Diseases*, 1-16.

Siriweera, W.I. (1982) Water Resources and Cattle and Buffalo rearing in Sri Lanka; A historical perspective. ARTI publication, (30).

Sok, J., Hogeveen, H., Elbers, A.R.W. and Lansink, A.O. (2016) Using farmers' attitude and social pressures to design voluntary Bluetongue vaccination strategies. *Preventive veterinary medicine*, 133: 114-119.

Sones, K.R., Duveskog, D. and Minjauw, B. (2003) Farmer Field Schools: the Kenyan experience. Report of the Farmer Field School stakeholders' forum held 27th March 2003 at ILRI, Nairobi, Kenya. FAO/KARI/ILRI, Nairobi, Kenya, p58.

Statham, J. and Green, M. (2015) Cattle veterinary services in a changing world. *Veterinary Record*, 176(11): 276-280.

Steinfeld, H., Gerber, P., Wassenaar, T.D., Castel, V., Rosales, M., Rosales, M. and de Haan, C. (2006) Livestock's long shadow: environmental issues and options. Food & Agriculture Organization, p390.

Stringer, A.P., Bell, C.E., Christley, R.M., Gebreab, F., Tefera, G., Reed, K., Trawford, A. and Pinchbeck, G.L. (2011) A cluster-randomised controlled trial to compare the effectiveness of different knowledge-transfer interventions for rural working equid users in Ethiopia. *Preventive veterinary medicine*, 100(2): 90-99.

Sturgess, G. W. (1900) Report of the Government Veterinary Surgeon, Ceylon Administration Report.

Subramaniam, S., Pattnaik, B., Sanyal, A., Mohapatra, J.K., Pawar, S.S., Sharma, G.K., Das, B. and Dash, B.B. (2013a) Status of Foot-and-mouth Disease in India. *Transboundary and* *emerging diseases*, 60(3):197-203.

Subramaniam, S., Sanyal, A., Mohapatra, J.K., Sharma, G.K., Biswal, J.K., Ranjan, R., Rout, M., Das, B., Bisht, P., Mathapati, B.S. and Dash, B.B. (2013b) Emergence of a novel lineage genetically divergent from the predominant Ind2001 lineage of serotype O foot and mouth disease virus in India. *Infection, Genetics and Evolution*, 18: 1-7.

Sumption, K., Domenech, J. aschend Ferrari, G. (2012) Progressive control of FMD on a global scale. *Veterinary Record*, 170(25): 637-639.

Sutmoller, P., Barteling, S.S., Olascoaga, R.C. and Sumption, K.J. (2003) Control and eradication of foot-and-mouth disease. *Virus research*, 91(1): 101-144.

Tan, A.H. (1999) Text mining: The state of the art and the challenges. In Proceedings of the PAKDD - workshop on knowledge discovery from advanced databases 8: 65-70.

Thompson, D., Muriel, P., Russell, D., Osborne, P., Bromley, A., Rowland, M., Creigh-Tyte, S. and Brown, C. (2002) Economic costs of the foot and mouth disease outbreak in the United Kingdom in 2001. *Revue scientifique et technique (International Office of Epizootics)*, 21(3): 675-687.

Thomson, G.R. (2009) Currently important animal disease management issues in sub-Saharan Africa. *Onderstepoort Journal of Veterinary Research*, 76(1): 129-134.

USAID (2011) The KAP survey model (knowledge, attitudes and practices), United States Agency for International Development, Accessible at http://tinyurl.com/ok9p71y

Upjohn, M.M., Pfeiffer, D.U. and Verheyen, K.L. (2014) Helping working Equidae and their owners in developing countries: Monitoring and evaluation of evidence-based interventions. *The Veterinary Journal*, 199(2): 210-216.

Vaarst, M., Byarugaba, D.K., Nakavuma, J. and Laker, C. (2007) Participatory livestock farmer training for improvement of animal health in rural and peri-urban smallholder dairy herds in Jinja, Uganda. *Tropical Animal Health and Production*, 39(1): 1-11.

Valeeva, N.I., Lam, T.J.G.M. and Hogeveen, H. (2007) Motivation of dairy farmers to improve mastitis management. *Journal of Dairy Science*, 90(9): 4466-4477.

Van Den Borne, B.H.P., Jansen, J., Lam, T.J.G.M. and Van Schaik, G. (2014) Associations between the decrease in bovine clinical mastitis and changes in dairy farmers' attitude, knowledge, and behavior in the Netherlands. *Research in veterinary science*, 97(2): 226-229.

Vandamme, E. (2009) Concepts and challenges in the use of knowledge-attitude-practice surveys: Literature review. Department of Animal Health, Institute of Tropical Medicine, Antwerp, Belgium. 1:1-7.

Vernooij, A.G., Houwers, H.W.J. and Zijlstra, J. (2015) Old friends-new trends: emerging business opportunities in the dairy sector of Sri Lanka, Wageningen UR , *Livestock Research*.

Vidanarachchi, J.K., Chathurika, H.M.M., Dias, H.M. and Gedara, P.M.K., Silva, G.L.L.P., Perera, E.R.K. and Perera, A.N.F. (2019) Dairy industry in Sri Lanka: current status and way forward for a sustainable industry. Faculty of Agriculture, University of Peradeniya, Sri Lanka.

Vosloo, W., De Klerk, L.M., Boshoff, C.I., Botha, B., Dwarka, R.M., Keet, D. and Haydon, D.T. (2007) Characterisation of a SAT-1 outbreak of foot-and-mouth disease in captive African buffalo (Syncerus caffer): clinical symptoms, genetic characterisation and phylogenetic comparison of outbreak isolates. *Veterinary microbiology*, 120(3-4): 226-240.

WHO (2008) World Health Organization, Advocacy, communication and social mobilization for TB control: a guide to developing knowledge, attitude and practice surveys, No. WHO/HTM/STB/2008.46.

WRLFMD (2020) World Reference Laboratory for Foot and Mouth Disease, FMD virus pools and predominant virus serotypes Accessed on: http://www.wrlfmd.org

Warren, D.M. (1991) Using indigenous knowledge in agricultural development (No. 127). World Bank.

Weese, J.S., Peregrine, A.S. and Armstrong, J. (2002) Occupational health and safety in small animal veterinary practice: Part I—Nonparasitic zoonotic diseases. *The Canadian veterinary journal*, 43(8): 631.

Wellard, K., Rafanomezana, J., Nyirenda, M., Okotel, M. and Subbey, V. (2013) A review of community extension approaches to innovation for improved livelihoods in Ghana, Uganda and Malawi. *The Journal of Agricultural Education and Extension*, 19(1): 21-35.

Wickramasuriya, U. G. J. S., Peiris, G. S., Kendaragama, K. M. T. and W. M. Karunadasa. (1983) A survey on the incidence of bovine brucellosis in three districts of Sri Lanka. *Sri Lanka Veterinary Journal,* 31: 27-31.

Wiethoelter, A.K., Beltrán-Alcrudo, D., Kock, R. and Mor, S.M. (2015) Global trends in infectious diseases at the wildlife–livestock interface. *Proceedings of the National Academy of Sciences*, 112(31): 9662-9667.

Wijewardana, B.D.R. and Fernando, W.W.H.S. (1983) The position of foot and mouth disease in Sri Lanka during 1977-1981. *Rev sci. tech. Off. Int. Epiz*, *2*: 171-176.

Windsor, P.A. (2011) Perspectives on Australian animal health aid projects in South-East Asia. *Transboundary and Emerging Diseases*, 58(5): 375-386.

Windsor, P.A., Freeman, P.G., Abila, R., Benigno, C., Verin, B., Nim, V. and Cameron, A. (2011) Foot and Mouth Disease Control and Eradication in the Bicol Surveillance Buffer Zone of the Philippines. *Transboundary and emerging diseases*, 58(5): 421-433.

Wolf, C.A. (2005) Producer livestock disease management incentives and decisions. *International Food and Agribusiness Management Review*, 8(1): 46-61.

Wolmer, W. and Scoones, I. (2005) Policy processes in the livestock sector: Experiences from the African Union. African Union/Inter-African Bureau for Animal Resources, Nairobi.

World Bank (2018) Poverty overview, Accessible at http://www.worldbank.org/en/topic /poverty/overview

Yamanishi, K. and Li, H. (2002) Mining open answers in questionnaire data. IEEE Intelligent Systems, 17(5): 58-63.

Yoshikawa, Y., Uchida, J., Kosoku, A., Akazawa, C. and Suganuma, N. (2019) Childbirth and are difficulties of female kidney transplantation recipients, *Transplantation proceedings* (51)5: 1415-1419.

Young, E.J. (1995) An overview of human brucellosis. *Clinical infectious diseases*, 21(2): 283-289.

Young, J.R., Suon, S., Olmo, L., Bun, C., Hok, C., Ashley, K., Bush, R.D. and Windsor, P.A. (2017) Investigation of smallholder farmer biosecurity and implications for sustainable foot-and-mouth disease control in Cambodia, *Transboundary and emerging diseases*, 64(6): 2000-2012.

Zemmelink, G., Premaratne, S., Ibrahim, M.N.M. and Leegwater, P.H. (1999) Feeding of dairy cattle in the Forest-Garden farms of Kandy, Sri Lanka. *Tropical Animal Health and Production*, 31(5): 307-319.

Zheng, T. (2017) A literature review on knowledge sharing. *Open Journal of Social Sciences*, *5*(3): 51

Özlü, H., Atasever, M. and Atasever, M.A. (2020) Knowledge, attitude, and practices of cattle farmers regarding zoonotic diseases in Erzurum, Turkey. *Austral journal of veterinary sciences*, *52*(3): 79-85.

要旨

スリランカでは、家畜が農村経済に不可欠な役割を担っており、農村社会の生計を支えている。家畜の病気の中でも口蹄疫（FMD）は、死亡率は低いものの感染力が強く、生産に経済的影響をもたらし、スリランカの畜産部門の発展を妨げている。特に、東部州の風土病であり、大流行を招いて他州にも影響を及ぼす可能性がある。口蹄疫対策としては、感染家畜の特定、発生源の追跡、規制、検疫、移動制限、ワクチン接種、衛生管理がある。財政的制限のため、先進国で行われているような感染家畜の殺処分や農家への補償は行われていない。予算制約の中で口蹄疫の発生を防ぐための効果的な対策の検討が必要である。本調査の主目的は、口蹄疫の発生状況および関連する農家の行動を明らかにし、スリランカにおける効果的な制御戦略のための情報を提供することである。既往文献のレビューに基づき、酪農家の知識・態度・実践、口蹄疫ワクチン接種、口蹄疫対策への農家行動を、口蹄疫の効果的な制御要因として特定した。スリランカでは、これらの点について十分な調査が進んでいない。したがって、具体的には以下の視点から接近していく。

1) 口蹄疫に関する農家の知識・態度・実践（KAP）を特定すること
2) 口蹄疫対策のための農家のワクチン接種行動に影響を及ぼす要因を調べること
3) 口蹄疫の治療と抑制に関して農家に根付いている伝統的行動習慣を明らかにすること

東部州の Ampara 地区では、Kalmunai (KAL)、Navithanveli (NAV)、Sammanthurai (SAM) の地区（それぞれに獣医局あり）が口蹄疫の大きな影響を毎年受けているため、これら三地域を本調査の対象とすることにした。これらの地域の民族は、主にムスリムとタミールで、それぞれ畜産に従事している。政府の獣医局で入手できる農場登録のリストをサンプリング抽出枠として使用し、三地域から無作為に 60 名の農家を同じ割合で選出し、合計 180 名の回答者を抽出した。本調査は、牛及び水牛を飼育している小規模及び

大規模畜産農家を対象に行い、2019 年 9 月から 10 月にかけて実施した。データは質問票を介して農家から収集し、彼らの母国語（タミル語）での対面調査による聞き取りを行った。構造型の質問票を用いて、社会・農場要因、家畜訓練プログラム、口蹄疫ワクチン接種の有無、口蹄疫発生経験、口蹄疫ワクチン接種済の家畜数、家畜生産に関わる農家の伝統的行動を考慮に入れた本調査の目的上必要な情報をすべて収集した。

農村部の畜産農家の KAP を改善することは、口蹄疫の予防に大きな影響を与える可能性がある。本研究の第一目的は、酪農家の間における口蹄疫に関する基本的な農家の KAP 水準を調査・評価し、分析結果は第 3 章にまとめられた。各農家の KAP への社会的要因及び農場要因の影響を分析するために回帰モデルを使用し、これらの要因と KAP レベルを比較するために t-検定を適用した。口蹄疫に関する全体的な知識及び実践のスコアは、それぞれ 4.36 と 2.46 であった。農家の態度に対するスコアは 3.49 で、知識、態度、実践に対する最大スコアはそれぞれ 4.38、3.50、3.04 であった。回答者のうち 89%が、獣医局に対して口蹄疫は主な家畜の病気の一つであると報告した。農家の教育レベルは、口蹄疫に関しては KAP に正の影響を与えた($p < 0.05$)。5 年以上の農業経験があり、家畜管理及び牛の飼育に関する訓練プログラムに参加した結果も、口蹄疫に関する KAP の向上に有意に影響していた（$p < 0.05$）。家畜の健康状態を改善するためには、効果的な疾病管理のための教育及び訓練を通じて、牛の使用管理における農家の KAP を強化することが必須となる。

第二の研究目的を解明するため、第四章では農家の口蹄疫ワクチン接種行動に関する分析を第 4 章で行った。これは口蹄疫ワクチン接種の有無と牛個体の接種率に影響を与える要因の特定を目的とするものである。プロビット回帰モデルとトービット回帰モデルを適用して、口蹄疫ワクチン接種の参加行動への要因を特定した。口蹄疫の知識及び衛生管理の知識に対するスコアは、平均して、それぞれ 54.5%と 49.2%であった。口蹄疫に関する農家の知識水準は、性別、教育レベル、農家訓練プログラムの参加と強い関連があった（$p < 0.01$）。ワクチン接種行動は、家畜の数、農業経験、口蹄疫の知識水準

が統計的に有意で（$p < 0.05$)、家畜衛生管理も統計的に有意であった（$p < 0.1$)。以上より、酪農家のおかれる社会的要因及び農場特性が、口蹄疫の知識とワクチン接種行動に寄与していることが明らかになった。スリランカにおける口蹄疫対策として、家畜に関する教育訓練プログラムを通して、ワクチン接種への参加意欲を高めること等が求められた。

第三の研究目的は、農家の伝統的な口蹄疫対策を特定し、口蹄疫の発生を防ぐ、より効果的な方法を採用するために、農家の行動変容をうながす方法を明らかにすることで、この分析は第 5 章で行った。分析では、口蹄疫の治療と予防に関し自由記述の回答の得られた、三地域で 87 名のサンプルを利用した。自由記述の質問で得られたサンプル数は、KAL、NAV、SAM の三地域でそれぞれ 34、38、15 であった。テキストマイニングの手法を用いて、口蹄疫の治療と予防に対する農家の行動を調べた。テキストマイニングソフトとして広く用いられている KH Coder を使って、農家の固有の行動をサンプル全体と二つの人種について、単語抽出頻度と共起ネットワークから特定した。共起の相対的な強さに関しては、テキスト中のキーワードの組み合わせすべてについて、ジャカード係数の値を算出した。その結果、「ワクチン」の頻度が他の農家の行動習慣よりも高いことが分かった。「ワクチン」と「獣医局」の間のジャカード係数は、二つの習慣の間の他の係数よりも高かった (0.36)。サンプル全体では、「ワクチン」、「獣医局」、「伝統的習慣」、「創傷治療」が一つのグループとして強く関連していた。「創傷剤」と「塩水」の使用は一つのつながりとして関連づけられている、こと等が明らかとなった。農家に固有の埋め込まれた行動の分析結果は、口蹄疫発生時の治療と対策に役立つ情報を提供しており、社会に埋め込まれた行動習慣を変えることで将来の口蹄疫対策の効果的実施に寄与することができる。農家に根付いた固有の行動を変化させることが、病気の予防と管理における口蹄疫管理アプローチの成功にとって重要であることが解明された。

FMD はスリランカの特に東部州における風土病となっている。そのため、口蹄疫は、

制御および根絶すべき最優先の家畜疾病として位置づけられている。結論として、口蹄疫に対する農家の KAP 水準は低く、この低さが、口蹄疫感染、ワクチン接種、バイオセキュリティにおけるリスクを伴う農業行動につながることが分かった。これは、明らかに本調査の対象集団の農家における情報の非対称性という状況を示すもので、現在、政府が行う農家訓練は口蹄疫の発生を抑制するのに十分ではないことが示された。

本研究結果は、現在、政府が行う農家訓練啓発プログラムでは口蹄疫対策の社会・経済的側面をより考慮すべきである、ということを明確に示している。この調査結果は、スリランカだけでなく他の発展途上国にも応用することができる。農家の KAP に関する分析により、以下のような口蹄疫対策についての有益な情報が明らかになった。すなわち、口蹄疫ワクチン接種を奨励するためには、地域の獣医局で頻繁に農家訓練プログラムを行い、口蹄疫の影響とその対策について農家を教育する必要がある。農家訓練プログラムについては、衛生管理、口蹄疫に感染した動物の隔離、口蹄疫発生時の動物の移動制限、ワクチンプログラムの推奨等、現状の農家トレーニングでは行われていない点を考慮すべきである。農家の知識を向上させ、社会に定着した固有の行動を変えることは、動物の効果的な疾病管理において極めて重要である。以上の解明された FMD の持続的制御戦略がスリランカにおける家畜疾病管理政策において重要となる。

Appendices

Questionnaire format

1. General information

Name of the farmer:

Address:

Telephone No:

Veterinary surgeon's range (Area):

2. Family information

2.1 No. of members in the family (at present):

2.2 Age of head of Farmer:

2.3 Gender

1. Male 2. Female

2.4 Education level of the farmer

1. No school	2. up to grade 5	3. up to O/L	4. up to A/L	5. Above A/L

2.5 What is the main job of the farmer

1. Livestock	2. Private	3. Labour
4. Agriculture	5. Government	6. Other (specify)

2.6 Who is the decision maker of the dairy farm?

1. Male 2. Female

3. Farm detail

3.1 Do you register the farm? 1. Yes 2. No

3.2 Details of livestock and number at present: 1. Cattle --------- 2. Buffalo ----------

3.3 Type of livestock management: 1. Intensive 2. Semi-intensive 3. Extensive

3.4 Feeding system of livestock: 1. Outside 2. Cut & feed 3. Paddy land 4. Graze land

4. Animal movement

4.1 Animals sent for grazing during day time: 1. Yes 2. No

4.2 Who is responsible for the primary care of livestock?

1. Husband	2. Wife	3. Children	4. Other

5. Family income

5.1 Dairy farm

5.1.1 Income from milk/month (Rs): ---------- (%)

5.1.2 Animal sales/last year (2018)

No. of animal sale a) < 1-year b) 1-4 years c) > 4 years

5.1.3 Price per animal (Rs)

5.1.4 Has your livestock herd increased or reduced over last 4-5 years - yes (increased) / No (Reduced)

5.1.5 Income from manure sale / year (Rs): -----------(%)

5.2 Other livestock income/ year (Rs): ------------(%)

5.3 Crop income /year (Rs): -------------- (Rice, maize, vegetable etc %)

5.4 Off farm information

5.4.1 Off farm family income / month (Rs); ------------

5.4.2 Off farm activity and income (Rs):

a) Government	b) Private	c) Labour
d) Foreign remittance	e) Agriculture	e) Nothing

5.5 Do you get Samurdhi? 1. Yes 2. No

6. Training and Experience on animal Husbandry

6.1 Have you had training on animal husbandry for one day or more in last year 2018

1. Yes 2. No

6.2 If yes, what kind of training (multiple answers)

1. Milk hygiene	2. Feeding & nutrition	3. Livestock diseases
4. Biosecurity	5. Pasture cultivation	6. Vaccination (FMD, HS)

6.3 If yes, institution that was conducted

1. Vet office	2. MILCO	3. Training centre	4. Vidatha
5. NGO	6. Other company	7. Do not know	

7. Farming experience

7.1 Are you a parent's dairy farmer? 1. Yes 2. No

7.2 How long do you engage in dairy farming?

1. < 1 year	2. 1-5 years	3. 5-10 years
4. 10-20 years	5. > 20 years	

8. FMD Vaccination

8.1 Were your animals vaccinated against FMD this year 2019? Yes/ No

If yes how many animals? ---------

8.2 Did you vaccinate FMD last year 2018? Yes/No

If yes how many animals? ---------

8.3 At what age, animal get first FMD vaccine? -------

8.4 How many times FMD vaccinate per year is correct? 1. one time 2. Two time 3. Do not know

8.5 Any FMD outbreak occurred in your farm, when? 1. Yes 2. No

8.6 Do you know where to get FMD vaccine? 1. Yes 2. No

If yes, where?

8.7 Do you think vaccination card is useful? 1. Yes 2. No

Farmer Knowledge, Attitudes and Practices (KAP) on FMD

1. Knowledge about FMD (read the statement and circle)

1.1 Do you know about a disease – FMD? Yes / Have heard / No

1.2 If yes

1.2.1 Milk production will be reduced True / False / Do not know

1.2.2 Animals will be lameness True / False / Do not know

1.2.3 Salivation from mouth True / False / Do not know

1.2.4 Animal will be blind True / False / Do not know

1.2.5 Animals will get blisters in mouth True / False / Do not know

1.2.6 FMD is transmitted from animal to human True / False / Do not know

1.2.7 FMD is transmitted by air True / False / Do not know

1.2.8 1st FMD vaccination at age of one year True / False / Do not know

2. Practices related to FMD infection

2.1 Use boots or slippers in handling animals Yes / No

2.2 Use detergents to clean hands after handling animals Yes / No

2.3 If sick animal by FMD not send for grazing Yes / No

2.4 Separate disease animals from others Yes / No

3. Animal purchases from outside

3.1 Have you purchased animal from outside farms 2017/2018? Yes / No

3.2 If yes, from where: Within area / Same district / Same province / Another province

3.3 What is your concerns when purchase (multiple answers)

Milk yield / Health of animal / Body condition / price

3.4 Did you sell sick animals? Yes / No

3.5 Did you get good price for sick animal? Yes / No

4 Veterinary assistance

4.1 Did you report the suspected FMD cases to the authority? Yes / No

4.2 How do you report? Phone / Visit / Other (specify)

4.3 Does VS normally attend to the cases in working days? Yes / No

4.4 Do you treat FMD cases without inform to GVSO? Yes / No

If yes how? -------------------

Hygiene knowledge (Bio-security)

1. The spread of FMD can be stopped by selling affected animal True / False / Do not know
2. Regular vaccination can prevent my cattle getting FMD True / False / Do not know
3. Vaccine and antibiotic are the same True / False / Do not know
4. My cattle can get FMD if I mix with newly bought cattle True / False / Do not know
5. Keeping my sick cattle away from other animals helps to ensure other cattle in the village do not get sick True / False / Do not know
6. Using the same food and water buckets for sick and healthy cattle is ok True / False / Do not know
7. Each time after you contacted infected animals did you clean yourself and change your clothes before going to other area? Yes/ how? No/ why?
8. What disease gives the signs of - swelling in neck area, quick and difficult breathing, death and many affected cattle or buffalo affected at one time:

I do not know / HS / FMD / Name the disease-------

Farmers' perception

What do you think about FMD? 1. Has big impact 2. Has an impact 3. No impact

What do you think about FMD vaccination? 1. Very effective 2. Effective 3. Not effective

Do you prefer to pay a nominal fee (Rs.10) and get the vaccine? Yes / No

How do you treat FMD? ---------------------

How do you prevent FMD? --------------------

Acknowledgement

I would like to offer my immense gratitude to my academic main advisor, Professor Hiroichi Kono, Department of Agro-environmental Science, Obihiro University of Agriculture and Veterinary Medicine for his kind and generous valuable guidance, encouragement, supervision and advice extended me throughout my study in Japan. Vast knowledge and research of economic and epidemiological study on animal diseases are the interest of agricultural economics in developing countries was more support to complete the thesis successfully. My heartiest thank you.

I would like to express my heartfelt thanks to Assistance Professor Satoko Kubota, whose kind advice, encouragement, support and invaluable comments has given to improve my study.

I would like to thanks to Associate Professor Hiroyuki Iwamoto for the valuable comments and advice for improve my study.

I also very grateful to thank my co-supervisors Professor Toshihisa Kanayama and Professor Yasushi Sembokuya for their many insight suggestions in improving my works.

Moreover, I would like to express to thanks Associate Professor Tomas Acosta for his valuable comments and advice.

I need to thanks my lab mates Eisuke Kieda, Shelton M Nhokwara, Finaritra Solomampionona, Kato Keisuke and for their support and assistance during the life in Obihiro and who create good atmosphere in the lab.

Further I wish to thanks International Student Office and Admissions and Educational Affairs Section, Obihiro University of Agriculture and Veterinary Medicine, especially Ms. Mizuki Chiba, Ms. Yuki Hara, Ms. Hattori Yukiko, Ms. Shimura Natsuno and Mr. Hiroshi Ishiyama for their assistance and kind encouragement in all means of support work.

Also, I thanks all my friends those I met in Obihiro University for making life comfortable. I would like to thank Obihiro University of Agriculture and Veterinary Medicine, Hokkaido, Japan for providing grants to study and Department of Animal production and Health, Sri Lanka for giving me this opportunity.

Dedication

This thesis is dedicated to my beloved wife A. L. Sithy Jesna and kind daughters; Fathima Anafa, Fathima Ithfa and Fathima Fatheen for their unconditional love, never-ending support and patience and encouragement throughout my study period in Obihiro University of Agriculture and Veterinary Medicine, also express my deep gratitude for their sacrifice, endure, understanding and accepting all hardships in my absence.

To my late parents for their unswerving support and encouragement in my education; and to my brothers and sister for their kindness and great support to attain this position.