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Constraints and opportunities to improve livestock production and health, and reduce zoonotic risks in small-scale native chicken, cattle and small ruminant farms in the Central Dry Zone of Myanmar

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Abstract

The Central Dry Zone (CDZ) supports 10 million people whose livelihoods depend on dry-land agriculture and small-scale livestock rearing. The CDZ has the highest livestock concentration in Myanmar, but characteristics of livestock production and health in this region have not been evaluated in detail. There is a need to understand the opportunities and limitations and for livestock production in the CDZ in order to develop methods to improve livestock production and disease control, to enhance the financial returns and living standards and, under the one-health paradigm, improve the nutrition and health status of farmers. Therefore, the objectives of this research were to describe husbandry and livestock health management and attitudes of small-scale cattle, small ruminant and village chicken farmers and to explore farmer's behaviours towards the prevention of livestock diseases and the risk of acquiring zoonotic diseases from livestock.

Cross-sectional studies were conducted with 613 cattle, sheep and goat and village chicken farmers in 40 villages of the CDZ and with 63 stakeholders associated with livestock trading. Farming practices were compared between different livestock ownership groups and logistic, ordinal and multinomial regression models were used to quantify the association between husbandry practices on livestock rearing outcomes (such as livestock health, biosecurity and income generation). Path analysis and multilevel mixed modelling were applied to identify factors that affect small-scale livestock farmers' decisions to vaccinate their livestock against Foot and Mouth Disease (FMD) and Newcastle Disease (ND). In addition, attitudes, beliefs and barriers to the application of recommended zoonotic disease prevention approaches and social networks of livestock movements and trading density were explored to identify their impact on farmer's perceptions on the risk of acquiring zoonotic diseases.

Multispecies rearing was a frequent occurrence with 51.7% (95%CI: 42-61%) of farmers rearing more than one livestock species. Rearing animals to be sold as adults for slaughter (meat production) was more common for small ruminants (98.1%) and chickens (99.8%) compared to cattle (69.8%). A substantial proportion of farmers in the CDZ derived their main income from crop production (43.2%), followed by livestock production (23.1%). Patterns of grazing differed between seasons ($p<0.05$) for cattle, but not for small ruminants. Larger cattle herds were more likely to practise grazing ($p< 0.001$) and farmers owning these herds were more likely to employ labour from outside the household to manage cattle compared to smaller herds ($p=0.03$). Amongst small ruminant households, larger flocks were kept by farmers with longer experience of small ruminant ownership ($p=0.003$). For village chickens, the provision of drinking water to birds was associated with larger flock sizes ($p=0.045$).

Clinical FMD and ND signs, respiratory and digestive disorders were the most common health problems. Health problems were associated with grazing practices, herd sizes and specific bio-security measures. The majority of livestock farmers (>70%) reported that they were aware of the risk and impact of FMD and ND and were willing to vaccinate their livestock (>60%). While the majority of cattle farmers were able to obtain information about vaccinations from local veterinary authorities (73.7%), many small ruminant (43.6%) and village chicken farmers (58.4%) were not able to access this information. Limited access to vaccines and vaccinators was related to size of villages ($p<0.01$ for cattle; $p=0.027$ for small ruminants; $p=0.005$ for village chickens). Willingness to vaccinate small ruminants against FMD was associated with the perceived impact of the disease on sales and accessibility of information about vaccination. Accessibility to information about ND vaccination influenced the willingness of village chicken farmers to conduct vaccinations. In addition, beliefs in the effectiveness of vaccinations played a major role in the willingness to carry out vaccinations on both, cattle ($p=0.018$) and village chicken farms ($p<0.001$).

The availability of information about zoonoses to traders influenced their confidence to implement preventive actions ($OR=1.5$, $p=0.045$ for cattle and $OR=1.5$, $p=0.022$ for village chicken diseases). Traders were more likely aware of zoonoses transmitted by cattle compared to livestock farmers ($OR=0.3$, $p=0.005$ for cattle farmers). Appropriate hand hygiene measures (i.e. cleaning of hands after touching, cutting or cooking meat) ($OR=7.7$, $p<0.001$ for zoonotic small ruminant and $OR=1.6$, $p=0.073$ for zoonotic village chicken diseases) and treating of sick animals ($OR = 7.3$, $p<0.001$ for small ruminant zoonotic and $OR = 2.2$, $p=0.031$ for village chicken zoonotic diseases) increased the confidence of small ruminant and village chicken owners to prevent zoonotic infections.

The findings from this research have the potential to inform policies aimed to enhance income derived from small-scale livestock production, to improve livestock breeding and disease control on a farm and village level and to develop strategies to enhance self-sufficiency in livestock production in Myanmar. They also provide the basis for key extension messages to improve livestock health and public health.

Declaration by author

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly-authored works that I have included in my thesis.

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<u>Contributions by others to the thesis</u>

Chapter 4: Characteristics of livestock husbandry and health management practices on small-scale, multispecies livestock rearing farms in Myanmar

Tu Tu Zaw Win contributed a total of 80% of research work including concept and design of the project, non-routine technical work, data management, analysis and interpretation of research data, formatting, drafting and editing of manuscript. Joerg Henning, principle supervisor, took 8% of advisory role, conception and design of the project, validating interpretation of results and manuscript editing. Angus Campbell contributed 6% of advisory role and manuscript editing. Ricardo J. Soares Magalhaes contributed 4% of advisory role and manuscript editing. Kyaw Naing Oo contributed 2% of advisory role and manuscript editing.

Chapter 5: Impact of husbandry and health management practices on summary measures for multispecies livestock rearing and on income generation from livestock farming in Myanmar

Tu Tu Zaw Win contributed a total of 80% of research work including concept and design of the project, non-routine technical work, data management, analysis and interpretation of research data, formatting, drafting and editing of manuscript. Joerg Henning, principle supervisor, took 8% of advisory role, conception and design of the project, validating interpretation of results and manuscript editing. Angus Campbell contributed 6% of advisory role, conception and design of the project and manuscript editing. Ricardo J. Soares Magalhaes contributed 4% of advisory role and manuscript editing. Kyaw Naing Oo contributed 2% of advisory role and manuscript editing.

Chapter 6: Factors influencing small-scale farmers' decisions to vaccinate their animals against common infectious livestock diseases

Tu Tu Zaw Win contributed a total of 80% of research work including concept and design of the project, non-routine technical work, data management, analysis and interpretation of research data, formatting, drafting and editing of manuscript. Joerg Henning, principle supervisor, took 12% of advisory role, conception and design of the project, validating interpretation of results and manuscript editing. Angus Campbell contributed 5% of advisory role and manuscript editing. Ricardo J. Soares Magalhaes contributed 2% of advisory role, conception and design of the project. Kyaw Naing Oo contributed 1% of advisory role.

Chapter 7: Perceptions of livestock value chain actors on the risk of acquiring zoonotic diseases from their livestock

Tu Tu Zaw Win contributed a total of 80% of research work including concept and design of the project, non-routine technical work, data management, analysis and interpretation of research data, formatting, drafting and editing of manuscript. Joerg Henning, principle supervisor, took the 6% of advisory role, validating interpretation of results and manuscript editing. Angus Campbell, contributed 4% of advisory role, conception and design of the project and manuscript editing. Ricardo J. Soares Magalhaes contributed 9% of advisory role, conception and design of the project, validating interpretation of results, and manuscript editing. Kyaw Naing Oo contributed 1% of advisory role.

Relationship between the research presented in this thesis and the DAHAT PAN Livestock Project

The work presented in this thesis represents a standalone research activity that was designed, carried out and summarized by the author of this thesis. The collection and analysis of the data presented in this thesis was performed by the author of this thesis and was not generated or conducted as part of the DAHAT PAN project. However, the work presented here complements the research activities of the DAHAT PAN project. The DAHAT PAN project is a livestock research project funded by Australian Centre for International Research (ACIAR) that focussed on small-scale livestock producers in the CDZ of Myanmar. In the DAHAT PAN project, two representative townships in regards livestock production were identified in the CDZ using a cluster sampling approach and then small-scale livestock producers were monitored in three selected villages. The DAHAT PAN project focussed on close interaction with individual livestock farmers and the monitoring of livestock production and health in selected households of the three villages, while the work presented in this thesis represents large scale epidemiological investigations of husbandry practices, syndromic health problems, disease prevention practices and the livestock trading in 40 villages of the two representative townships of the CDZ, selected for the DAHAT PAN project. Therefore the research findings outlined in this thesis are useful for the DAHAT PAN project and other future livestock projects that focus on interventions to improve livestock production and health.

Statement of parts of the thesis submitted to qualify for the award of another degree

- None

Research Involving Human or Animal Subjects

The ethical approval for conducting the interviews with farmers, and traders in the CDZ of Myanmar was provided by the University of Queensland Human Research Ethics Committee (approval number #2014001425) (Annex 1 and Annex 2).

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Keywords

Myanmar, small-scale farmer, livestock production, livestock health, livestock trading, trading network, health belief, vaccination, cattle, small ruminants, village chickens

Australian and New Zealand Standard Research Classifications (ANZSRC)

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ANZSRC code: 070106, Farm Management, Rural Management and Agribusiness, 10%

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ANZSRC code: 070199, Agriculture, Land and Farm Management not elsewhere classified, 10%

Fields of Research (FoR) Classification

0104 Statistics

FoR code: 0702, Animal Production, 20%

FoR code: 0707, Veterinary Sciences, 60%

FoR code: 1117, Public Health and Health Services, 20%

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LIST OF ABBREVIATIONS

μ:	Mean value
ACIAR:	Australian Centre for International Agriculture Research
AI:	Artificial insemination
CDZ:	Central Dry Zone
CHK:	Village chicken
CI:	Confidence interval(s)
Coef:	Beta coefficient
CTL:	Cattle
FAO:	Food and Agriculture Organization
FMD:	Foot and Mouth Disease
FPC:	Finite population correction
HH:	Household
IQR:	Interquartile rate
JICA:	Japan International Cooperation Agency
KOICA:	Korea International Cooperation Agency
LBVD:	Livestock Breeding and Veterinary Department
LIFT:	Livelihoods and Food security trust Fund
mm:	Millimetre
MoALI:	Ministry of Agriculture, Livestock and Irrigation
ND:	Newcastle Disease
NZAid:	New Zealand Agency for International Development
OIE:	World Organization for Animal Health
PSUs:	Primary sampling units
SR:	Small ruminant

SSUs:	Secondary sampling units
Std:	Standardized value
Svy:	Survey designed based results
UQ:	The University of Queensland
USAID:	United States Agency for International Development
VCAs:	Value chain actors
VCE:	Variance estimation

CHAPTER 1

INTRODUCTION

1.1 Background

Myanmar's economy is dominated by the agricultural sector including rice, crop and livestock production. According to the World Animal Health Organization (OIE), in 2008 there were a total of 12,900,000 cattle, 3,100,000 sheep and goats and 135,540,000 poultry in Myanmar (OIE 2009). Industrial production of livestock is limited and most livestock is raised by small-scale producers on 'backyard farms'. On these farms feeding is conducted in 'traditional' ways such as grazing around plantations and by supplying the residue or leftover crops and plants after harvesting to livestock (Devendra and Thomas 2002a, 2002b, Devendra, Thomas et al. 1997, Henning, Pym et al. 2007, Oo 2010). The Central Dry Zone (CDZ) is a major hub for crop and livestock production, with almost 50% of Myanmar's total animal population reared in this region. However, livestock production in the CDZ faces various constraints. The annual rainfall of around 600mm restricts the growth of fodder plants and crops in the CDZ. In addition, animal diseases such as Foot and Mouth Disease (FMD), Anthrax, Black Quarter, Haemorrhagic Septicaemia, Newcastle Disease (ND), and parasitic infections are common in Myanmar (Abila 2011, Arthur 2005, Bordier and Roger 2013, Cocks, Robertson et al. 2012, Coker, Hunter et al. 2011, Khaing 2009, OIE 2009, Oo 2010, 2013, 2014, Rweyemamu, Roeder et al. 2008, Smith 2012) and probably are also highly prevalent in the CDZ (LBVD 2014). Furthermore, the majority of the 47 official cattle markets in Myanmar are located in the CDZ. These cattle markets may be potential hubs for the spread of infectious diseases as animals from many different sources and different regions are brought together there. Traders and so-called middle men might play an important role in disease dissemination as they often buy animals directly from some farmers and sell them to other farmers (Henning, Khin et al. 2006, Henning, Pym et al. 2007, Henning, Pym et al. 2008, Oo 2010, Smith 2012).

This research project aimed to understand the opportunities and limitations for livestock production and health in the CDZ in order to develop methods to enhance production, improve disease control and thereby increase the livelihood of small-scale producers derived from livestock production. It also aimed to describe the attitude and practices of small-scale producers for the prevention of common livestock diseases and zoonoses in the CDZ.

1.2 Research Questions

1) What are the ownership patterns for various livestock species and what management and husbandry practices are used by small-scale livestock farmers in the CDZ of Myanmar?

2) What are the livestock health problems, health management and disease prevention practices conducted on small-scale cattle, small ruminant and village chicken farms in the CDZ of Myanmar?

3) Which factors influence small-scale farmer's decisions to implement disease prevention practices and vaccinate livestock against Foot and Mouth Disease (FMD) and Newcastle disease (ND) in the CDZ of Myanmar?

4) What attitudes, beliefs and barriers of livestock farmers and traders and trading practices are associated with the implementation of methods to prevent zoonotic disease transmission?

1.3 Objectives

The research objectives are as follows:

1) To describe animal husbandry practices and livestock ownership patterns on small-scale farms in the CDZ of Myanmar
    - Collect data on animal husbandry, including feeding practices, housing and breeding
    - Describe and quantify ownership patterns for various livestock species and characterise management and husbandry practices of small-scale farmers
    - Identify husbandry factors associated with selected outcome indicators, such as 'herd or flock size' and 'purpose of rearing

2) To identify production, health and livelihood parameters that can be compared between different livestock species and to analyse associations between these production and health parameters and farm management practices in the CDZ of Myanmar
    - Collect data on health problems, health management and disease prevention practices on small-scale cattle, small ruminant and village chicken farms

- Describe health problems, health management practices and income generated by farmers owning single species or combinations of cattle, small ruminants and/or village chickens
- Develop a biosecurity and livestock disease prevention index that can be compared between livestock species, estimate the income generated from livestock productions and identify livestock management factors influencing both these parameters.

3) To describe small-scale farmers' attitudes and behaviours towards implementing vaccinations against FMD and ND in the CDZ of Myanmar
    - Collect data on disease prevention practices, individual farmer's perception on FMD and ND, the effectiveness of and barriers to vaccination and various factors that could impact the likelihood of farmers to have their livestock vaccinated
    - Analyse the relationship between the perceptions of livestock farmers on barriers and benefits of FMD and ND vaccination and their willingness to practise vaccination against FMD in cattle and small ruminants and ND in village chickens.

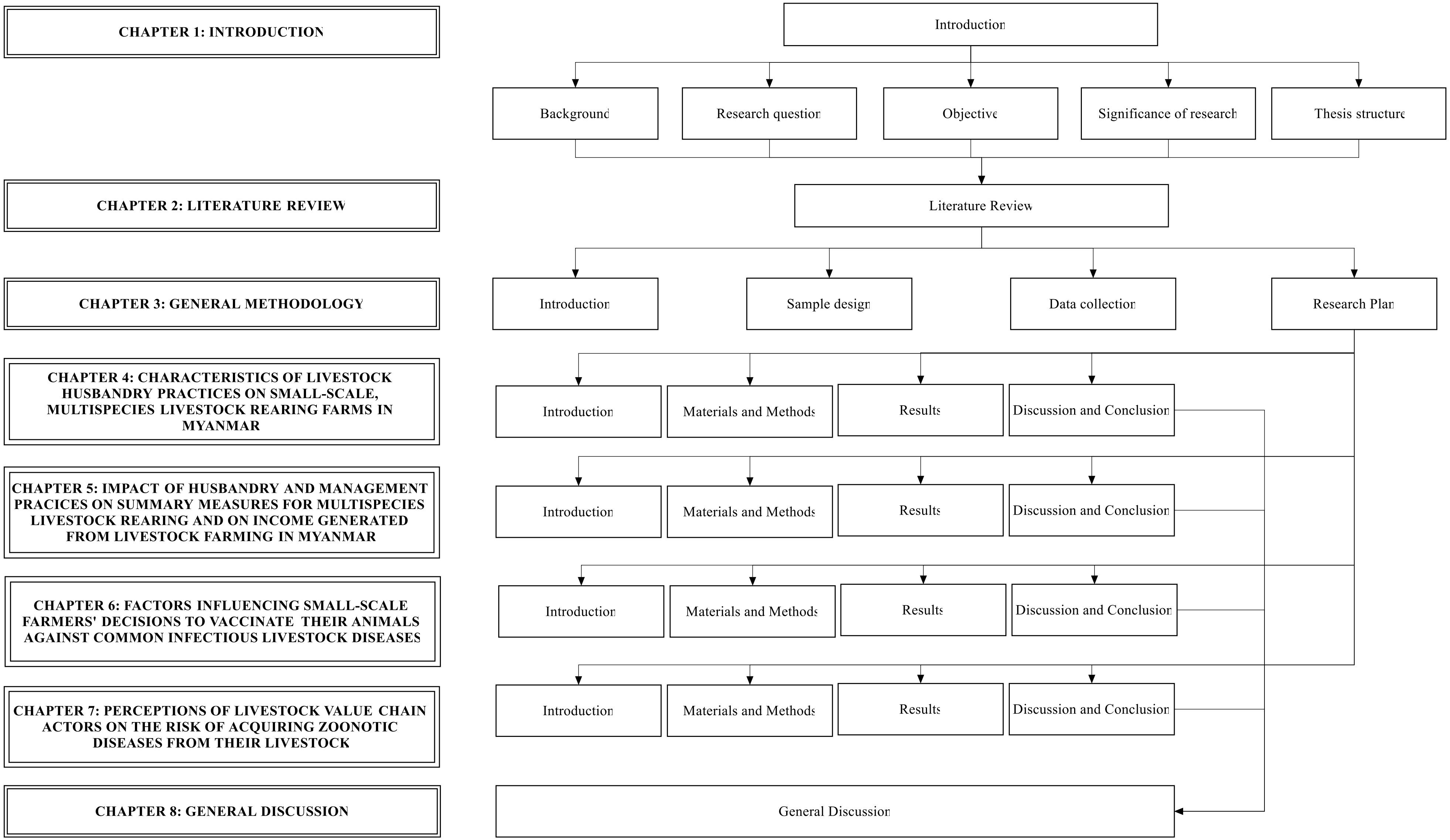
4) To describe the attitudes and awareness of small-scale farmers and livestock traders in the CDZ of Myanmar towards zoonotic disease prevention
    - Collect data on livestock trading networks
    - Collect data from small-scale farmers and livestock traders on attitudes, beliefs and barriers to the application of recommended zoonotic disease prevention
    - Describe livestock trading networks and model the impact of trading network parameters and of attitudes, beliefs and barriers of farmers and traders towards zoonotic disease prevention

1.4 Significance of the Research

There is a need to understand the limitations and opportunities for livestock production, health and socio-economic factors in the CDZ in order to develop methods to improve livestock production and disease control and also a need to understand farmers' behaviours and attitudes towards disease control. Overall, the results of this research will support the development of efficient, reliable and relevant strategies to overcome constraints in animal health and production, in order to enhance the financial return of small-scale producers and, under the one-health paradigm, improve the nutrition and health status of farmers in the CDZ of Myanmar.

As livestock production is a major income source and contributes to income and wealth of farmers' households in the CDZ of Myanmar, the research outcomes have the potential to inform policies aimed at improving the income of small-scale farmers derived from livestock production. The results from this study will provide recommendations for the development of policies for improved disease control and livestock breeding and for the development of extension messages to improve livestock rearing, health, biosecurity and public health. As research outcomes have a direct impact on small-scale farmers, the research outcomes are closely aligned with the Myanmar government goals for rural development: "to increase the income and living standard of rural people, whose livelihoods are strongly intertwined with agriculture" (Ministry of National Planning and Economic Development 2011, MOALI, FAO et al. 2018).

1.5 Structure of Thesis



CHAPTER 2

LITERATURE REVIEW

2.1 Myanmar and CDZ profile - location and climate

The Republic of the Union of Myanmar, also known as Burma, is situated in South East Asia and is bordered in the north and north-east by China; in the east and south east by Laos and Thailand; in the west by India and Bangladesh; in the south and south west by the Andaman Sea and the Bay of Bengal (Figure 2.1). Myanmar is located between latitude 09° 32´ N and 28° 31´ N and longitude 92° 10´ E and 101° 11´E (MOFA 2014, Wikipedia 2015) (Figure 2.1).

The total area of Myanmar is 677,000 square kilometres (261,228 square miles). It is a land of hills and valleys and is rimmed in the north, east and west by mountain ranges forming a giant horseshoe. Enclosed within the mountain barriers are the flat lands of the Ayeyarwaddy, Chindwin and Sittaung Rivers where most of the country's agricultural land and population are concentrated (MOFA 2014, Wikipedia 2015).

Due to the large size of the country, Myanmar has diverse climate conditions. Seasonal changes in the monsoon wind directions create summer (March to May), rainy (June to October) and winter (November to February) periods (MOFA 2014, Wikipedia 2015). In Myanmar, there are five seasons: the pre-monsoon period from mid-April to mid-May, the monsoon period from mid-May to mid-October, post-monsoon from mid-October to end-November, the dry and cold season from end-November to mid-March, and the hot season from mid-March to mid-April (Htway and Matsumoto 2011).

The annual rainfall differs between regions depending on the intensity of the southwest monsoon rain. In Myanmar, the coastal areas of Rakhine and Tanintharyi regions receive the highest annual rainfall ranging from 4000 to 6000 mm while the Ayeyarwaddy delta receives 2000-3000 mm, followed by the Shan plateau with 1000-2000 mm (FAO 2011a). The CDZ is the driest region of Myanmar and receives an average annual rainfall of only 500-1000 mm, similar to arid and semi-arid areas of African countries such as Zimbabwe, Malawi and Zambia (Ellis, Kutengule et al. 2003, FAO 2011a, Hughes 1988, Ragab and Prudhomme 2002, Scoones 1997).

The average temperatures in Myanmar range from 21ºC to 34ºC in summer, and from 11ºC to 23ºC in winter. The highest temperatures are recorded in the months of March and April. The Central Dry Zone (CDZ) experiences the highest temperatures of all regions with 43ºC or above in summer compared to 36º in Northern Myanmar and 29ºC in the Shan Plateau.

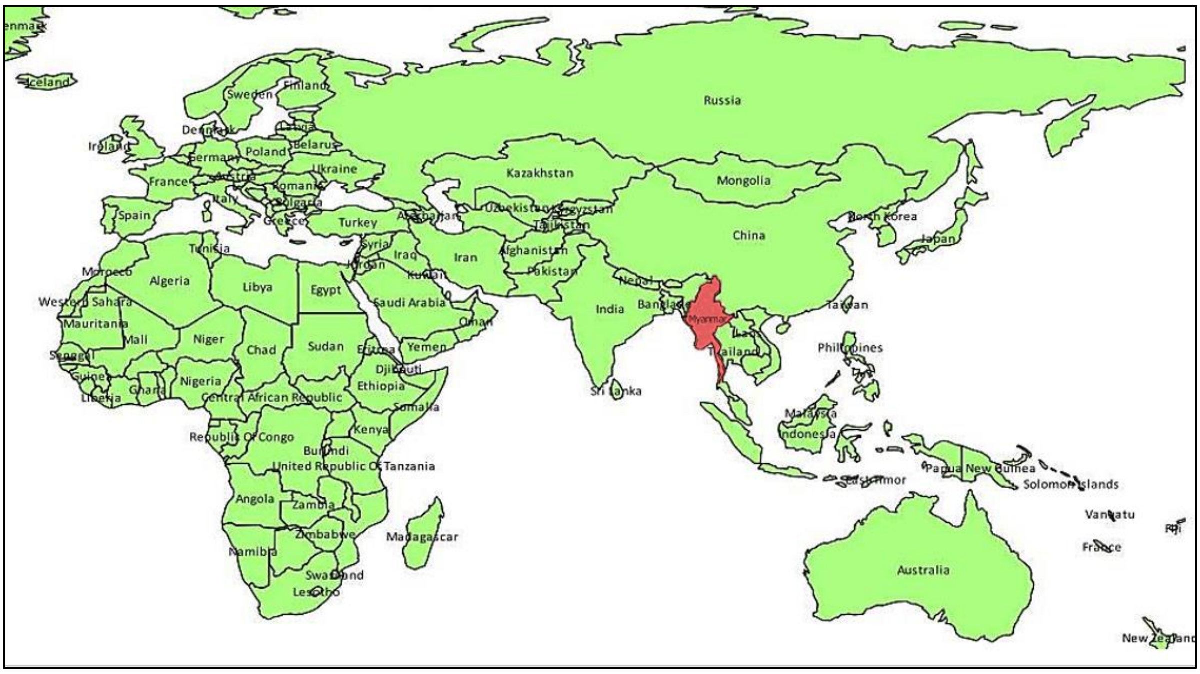


Figure 2.1 Location of Myanmar

The CDZ is 54,000 km long and encompasses 58 townships which are composed of three regions: Sagaing, Mandalay and Magway regions (MIMU 2018a) (Figure 2.2). The selected study areas in the CDZ were Meikhtila and Myingyan townships which are located in the Mandalay region. Meikhtila township is located between 95º 30'E 20º 40'N and 96º 00'E 21º 53'N, and Myingyan township is located between 95º 15'E 21º 20'N and 95º 37'E 21º 46'N. The climatic conditions in these townships are hot and dry and the maximum temperature all year round is ~40ºC (37.5ºC in Meikhtila township; 43.3ºC in Myingyan township) and the minimum temperature is ~10ºC (12.2ºC in Meikhtila township; 9.8ºC in Myingyan township) (MIMU 2018b, 2018c) .

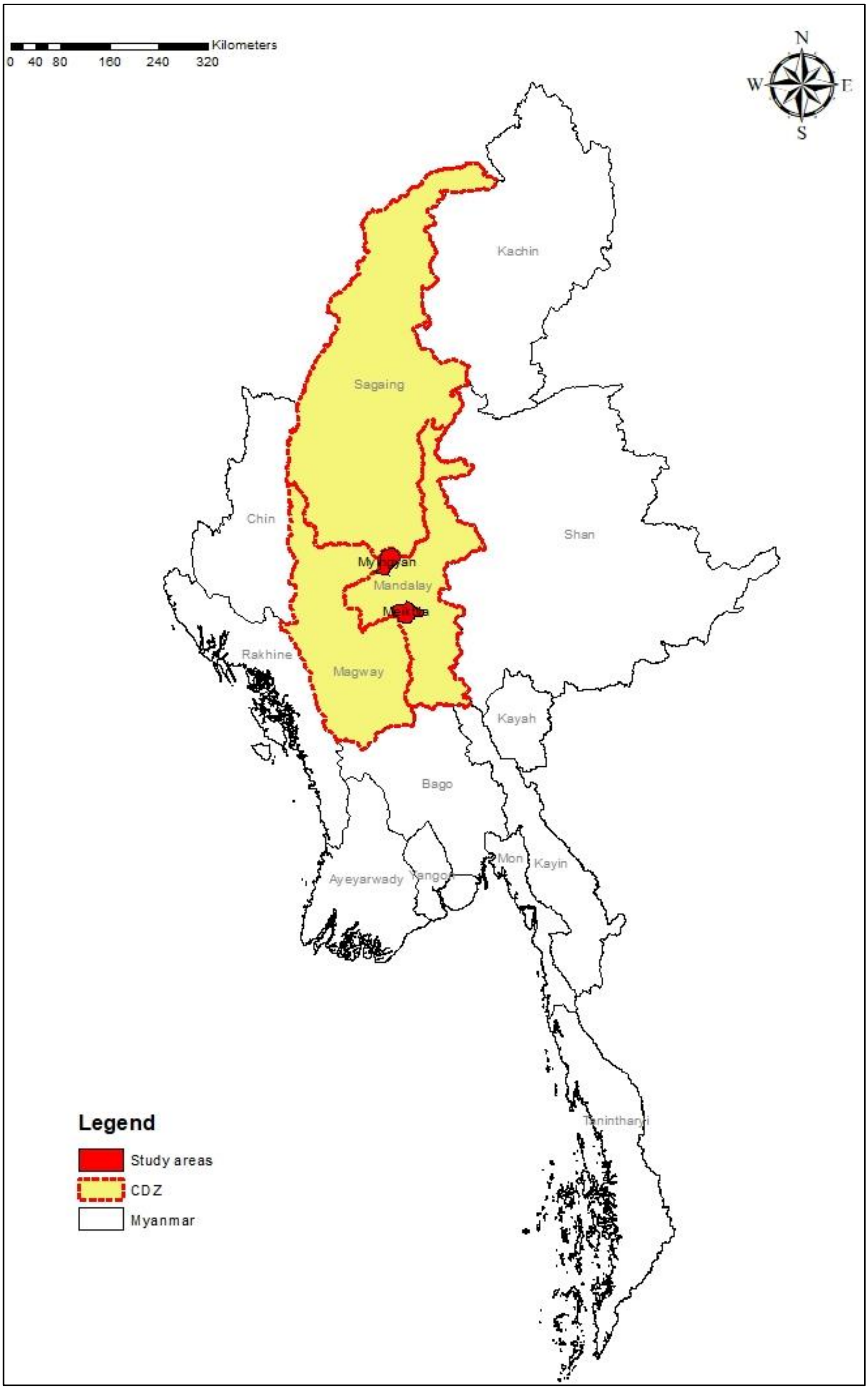


Figure 2.2 Location of study areas in CDZ of Myanmar

2.2 Livestock population in Myanmar and in the CDZ

2.2.1 Cattle population

According to FAO, the cattle population in South East Asia in 2010 was estimated to be around 439 million (Slingenbergh 2013). According to LBVD records, the total cattle population in Myanmar was approximately 16 million in 2015-2016. The Mandalay region, in which the CDZ is located, has the third largest cattle population in Myanmar of 2.3 million animals representing 15% of the total cattle population in Myanmar, while the Magway region had 2.8 million (18%) and the Sagaing region had 2.5 million (16%) cattle (Figure 2.3). The two townships of the Mandalay region which are the focus of this research project have approximately 100,000 cattle in Myingyan and about 150,000 cattle in Meikhtila (LBVD 2014) (Figure 2.4).

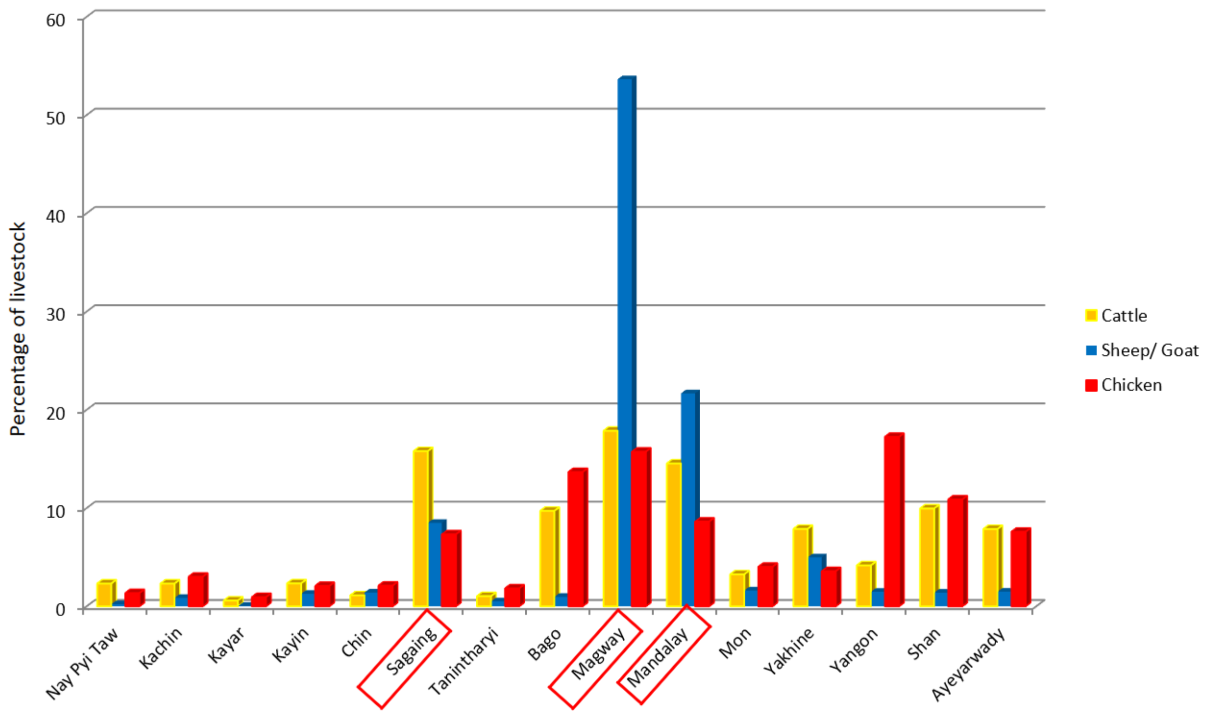


Figure 2.3 Percentage of livestock raised by regions (administrative areas) from the total livestock population in Myanmar. Highlighted red squares indicating regions within the CDZ (Data source: LBVD)

2.2.2 Sheep and goat population

The estimated sheep and goat population in South East Asia was 471 million in 2010 (Slingenbergh 2013). LBVD estimated the total sheep and goat population in Myanmar to be 7.7 million in 2015-2016. The Mandalay division has the second largest sheep and goat population in Myanmar of approximately 1.6 million representing 22% of the total small ruminant population in Myanmar, while the Magway region has the highest small ruminant population in Myanmar of 4.1 million animals (54%) (Figure 2.3). In the township of Myingyan, the small ruminant population was around 70,000 and in Meikhtila township it was 200,000 (LBVD 2014) (Figure 2.4).

2.2.3 Chicken population

Poultry production represents the largest livestock industry across the globe. According to FAO, the world chicken population was estimated to be 19.6 billion in 2010 (Slingenbergh 2013). Chicken production is divided into a commercial poultry production sector and a backyard farming sector. Backyard or village chicken production represents 80% of the total chicken production in Myanmar (Pym, Guerne Bleich et al. 2006). In 2015-2016, the total chicken population in Myanmar was approximately 270 million birds. In the Mandalay region, there were around 23 million birds, representing the fourth largest chicken population in Myanmar (9% of the total chicken population in Myanmar). Other states and division with a large chicken population were the Yangon region with 46 million birds (17% of Myanmar's total chicken population), followed by the Magway region (42 million birds, 16%), the Bago region (37 million, 14%) and the Shan State (29 million, 11%) (Figure 2.3). The estimated chicken population in the Myingyan township was 800,000 and in the Meikhtila township was 1.7 million birds (LBVD 2014) (Figure 2.4).

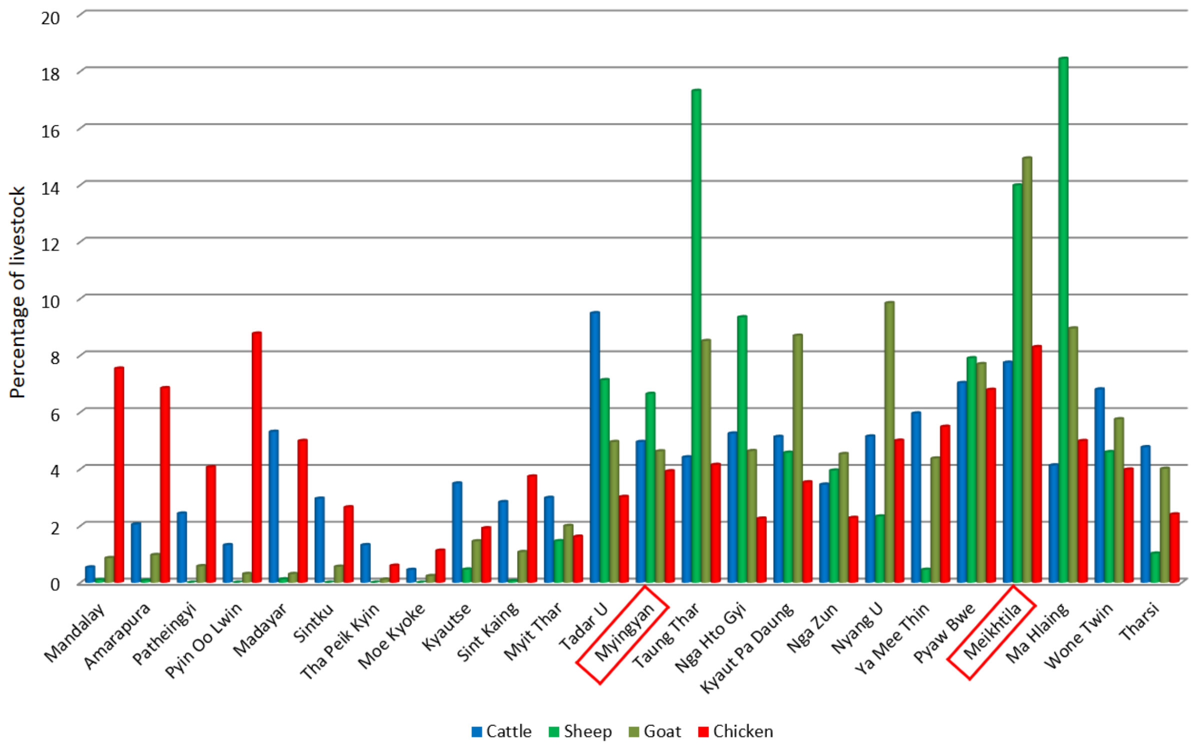


Figure 2.4 Percentage of livestock raised within different townships (administrative areas) in Mandalay region from the total livestock population in Mandalay region. Highlighted red squares indicating study areas (Data source: LBVD)

2.3 Small-scale livestock production in developing countries and in Myanmar

2.3.1 General characteristics of small-scale livestock production

In developing countries, small-scale farmers commonly practise integrated farming systems where livestock and crop production benefit from each other (Devendra and Thomas 2002a, Gillette 2013). For example, it has been estimated that 50-80% of total income of small-scale farmers in South East Asia is derived from integrated crop-animal production (Deshingkar, Farrington et al. 2008, McDermott, Staal et al. 2010, Nzuma and Baltenweck 2008). In contrast, in Zambia, Kenya and Sri Lanka, cattle farmers' main income is usually derived directly from cattle production (Moll, Staal et al. 2007). This highlights, that production methods, herd structures and values of individual animals might vary between countries (Blench and Marriage 1999, Mulder, Fazzio et al. 2010). In addition, poor rural communities are more likely to rear livestock than conduct other income earning activities (IGS Budisatria, HMJ Udo et al. 2007, FAO 2009, Kristjanson, Krishna et al. 2004, Morand-Fehr and Boyazoglu 1999).

Extensive and integrated farming is widely practiced by small-scale producers as it requires low investment, small inputs of labour, capital and housing (Devendra 1980, 1993, Devendra 1997, Gillette 2013) while income generated from livestock production by small-scale producers is often used to offset household expenditures. For example, in Eastern DR Congo, Sri Lanka and Indonesia, money generated from livestock is used to cover expenses associated with the preparation of rice fields, to pay the school fees, or emergency medical expenses (Budisatria, Udo et al. 2008, Maass, Katunga Musale et al. 2012, Samarajeewa, Schiere et al. 2003, Tarawali, Herrero et al. 2011). Village chicken production is usually not the main income source for small-scale farmers in the lower part of Myanmar (Henning, Khin et al. 2006, Kahan 2003). No information exists on the importance of livestock production for income generation by small scale farmers in the central part of Myanmar.

Multispecies rearing is very common in developing countries and small-scale producers prefer to raise 2-3 livestock species to supplement their income (Amenu, Markemann et al. 2013, LIFT 2014, Maass, Katunga Musale et al. 2012). However, most research conducted on livestock production focused on income generated from a single livestock species, ignoring the interactions between constraints and opportunities associated with raising multiple livestock species within a household.

2.3.2 Small-scale cattle production

Cattle production in developing countries is usually not conducted for a single purpose. For example, around 70-95% of cattle in South East Asia are used for draught power (Kahan 2003, Lawrence and Pearson 2002, Musemwa, Mushunje et al. 2008, Samarajeewa, Schiere et al. 2003), cattle manure is used to improve soil fertility and dry manure is often used for fuel (Chawatama, Mutisi et al. 2005, Devendra and Thomas 2002a, Kadohira, McDermott et al. 1997, Mulder, Fazzio et al. 2010, Musemwa, Mushunje et al. 2008, Thomas, Zerbini et al. 2002), while sale of animals and milk provide cash income to households (Chawatama, Mutisi et al. 2005, Mulder, Fazzio et al. 2010, Musemwa, Mushunje et al. 2008, Paris 2002, Remenyi and McWilliam 1986). Cattle production in Myanmar is also multipurpose: cattle are used for draught power, for breeding and for milking (HEA 2011, JICA 2010, Kahan 2003, LIFT 2014).

Large variations in cattle herd sizes have been reported for developing countries. For example, the average cattle herd size in East Africa ranges from 6 to more than 70 heads (Mdegela, Karimuribo et al. 2005, Ouma, Abdulai et al. 2007) while the cattle herd size in India is on average 2.2 per household (Erenstein and Thorpe 2010). It is also common in Asia that a single herd is owned by more than one person (Devendra 1986). Cattle herd sizes in Myanmar have been estimated to range from 1 to 6 head, depending on the wealth of the household (Devendra 1986, LIFT 2011). In the middle of Myanmar, cattle are either free roaming or they are kept in temporary yards, permanent buildings, closed pens or they are tethered in the grazing ground (Oo 2010).

Cattle graze traditionally around plantations, while some supplementary feed is also supplied (in particular to draught cattle) – a similar grazing management is practised in other developing countries (Blench and Marriage 1999, Li, Yuan et al. 2008, LIFT 2014, Long, Ding et al. 2008, Moll 2005, Shelton, Humphreys et al. 1987, Suttie 2003). However, detailed information on practices of feeding cattle in Myanmar is not available.

In addition to grazing, tree cropping, crop residues and other by-products are fed to cattle (Blench and Marriage 1999). Supplementary feed provided to cattle in Asian countries (Bhutan, China, India, Indonesia, Kampuchea, Korea DPR, Korea Rep, Laos, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam) include cereal straw (e.g. rice and maize), sugarcane tops, grain legume hays (e.g. groundnut and cowpea), root crop tops and vines (e.g. cassava and sweet potato), oilseed cake and meals (e.g. oil palm kernel cake, cottonseed cake and copra cake, coconut cake), rice bran and bagasse, cocoa pod husks, pineapple waste, cassava pomade, millet, sorghum straw, wheat straw, stovers, leucaena, crop residues, native grass, weed, tree foliage, cultivated forage crop, peelings of crops, elephant grass, legume leaves, banana waste, leaves, fruit waste, poultry litter and urea-treated rice straw (Budisatria, Udo et al. 2010, Devendra 1992, Devendra and Thomas 2002a, Renard 1977, Samarajeewa, Schiere et al. 2003, Smith 2012, Thomas, Zerbini et al. 2002) (Annex 3 and 5). Among these, rice straw is the most common fibrous feed resource used- it is provided to around 90% of all ruminants in Asia (Devendra 1992, Wanapat 1995).

Data on breeding management of cattle is scare for Myanmar. Castration of males is very common for draught cattle; these practices have been also described for Indonesia (Martojo 2003, Oo 2010).

2.3.3 Small-scale small ruminant production

Compared to other regions of Myanmar, sheep and goat production is widely practised in the CDZ as these species are adaptable and resistant to dry and hot weather (JICA 2010). No specific information on small ruminant herd structures exists for the CDZ.

Sheep and goat production is mainly conducted for the sale of animals, although some farmers rear sheep and goats also for milking (Devendra 1980, Kosgey 2004, LIFT 2014).

In developing countries of Asia and Africa, small ruminants are tied under shelters, tied without shelters or they are kept untied within enclosures. They might be provided with a slatted floor or earthen floor (IGS Budisatria, HMJ Udo et al. 2007, Jaitner, Sowe et al. 2001, Webb and Mamabolo 2004).

Grazing is also the most common feeding practice for sheep and goats, although some farmers keep young offspring at home and feed them there, because they consider young animals unfit for grazing (Blench and Marriage 1999). Grazing of small ruminants is usually overseen by one or two people (LIFT 2014). Similar by-products are fed to small ruminants as for cattle (Blench and Marriage 1999) (see above). In small ruminants, mainly males that are raised for export quality will be castrated, while it is not common to castrate other males.

No detailed information about breeding practices of small ruminants exists for Myanmar. Apparently only natural breeding is used for small ruminants, because artificial insemination is not available (Personal communication with Dr. Win Myint Thein and Dr. Aung Khaing Htwe) (Jaitner, Sowe et al. 2001, Kosgey, Rowlands et al. 2008, Webb and Mamabolo 2004).

2.3.4 Small-scale village chicken production

The main purpose of rearing village chickens in lower Myanmar is for the sale of live birds, followed by the sale of eggs, some breeding and for cock fighting - these purposes of village chicken keeping might be similar in CDZ (Choprakarn and Wongpichet 2007, Henning, Khin et al. 2006, Henning, Morton et al. 2009, Henning, Pym et al. 2007, LIFT 2014, Steinfeld 2003). Poultry flock sizes in Asian countries range between 5 to 20 birds (FAO 2004).

Households with several livestock species usually have only one village chicken flock, while households that only rear chickens often have several flocks (HEA 2011, LIFT 2011).

In lower Myanmar, village chickens are kept in a variety of ways overnight – they either rest under the house, inside the cow shed or sometimes in separate (temporary and permanent) buildings. If separate shelters exist, their walls are often made of bamboo, while nipah leaves are usually used for the roofs. Sometimes rice straw is provided for bedding, similar to what has been reported for neighbouring countries (Dutta, Islam et al. 2013, Henning, Pym et al. 2007).

Village chickens in lower Myanmar are mainly free scavenging with supplementary feed, such as broken rice and feed scraps, provided by farmers (Henning, Khin et al. 2006, Henning, Pym et al. 2007). This might be similar in the CDZ, although rice production is not practised in the CDZ, limiting the number of by-products available for feeding village chickens (LIFT 2014). The main supplementary feed sources used by small-scale poultry producers in Thailand and Bangladesh were household scraps and by-products from crop production (Choprakarn and Wongpichet 2007, Dutta, Islam et al. 2013, Henning, Khin et al. 2006, Henning, Pym et al. 2007, Leong and Jalaludin 1982).

Although some data on village chicken production exist for Myanmar, all the research was conducted in a specific region of the country and no information on village chicken production in CDZ is available.

2.4 Overview of constraints to small-scale livestock production in developing countries and in Myanmar

Livestock production in developing countries faces a number of constraints (Annex 3). These include effects of climate change, feed shortages, inadequate housing, lack of awareness about breeding, livestock diseases and veterinary support (Gillette 2013, Homann, Van Rooyen et al. 2007).

Feed and water availability impacts on the growth and performance of livestock, but shortages are also an important welfare issue (Bellaver and Bellaver 1999, Vanhonacker, Verbeke et al. 2008). Similar to other tropical developing countries, feed availability is a major concern for the CDZ - this is probably due to a shortage of grazing areas, a scarcity of good quality feed resources, limited property rights, high cost of concentrated feed, non-availability of supplementary feed and fodders, shortage of water and poor quality water (Amenu, Markemann et al. 2013, Chawatama, Mutisi et al. 2005, Kahan 2003, Maass, Katunga Musale et al. 2012, Mazumder, Kalita et al. 2014, Samarajeewa, Schiere et al. 2003, Steinfeld 2003). Access to water is important for livestock production. Water shortage is a major problem faced by people in CDZ especially in the dry season (Benedictus 1985, Blench and Marriage 1999, Kempel 2013). Various approaches are used in CDZ to provide livestock with water, such as water supply from tube wells, ponds, rivers, hand-dug wells, boreholes, dugouts or just roadside runoffs like in some African countries (Amenu, Markemann et al. 2013, Horowitz and Little 1987, Johnston, Ameer et al. 2013, LIFT 2014) (Annex 4 and 6).

As sale and marketing being the last stage of production, small scale livestock producers in developing countries are also faced with a number of challenges in this stage such as not being able to access markets (Chawatama, Mutisi et al. 2005), inadequate transport availability, poor availability of skilled labour (Hemme and Otte 2010, Mazumder, Kalita et al. 2014, Samarajeewa, Schiere et al. 2003, Thomas, Zerbini et al. 2002), loss of livestock due to theft (Kunene and Fossey 2010, Samarajeewa, Schiere et al. 2003) and predators (Henning, Pym et al. 2007, Maass, Katunga Musale et al. 2012). Beyond these challenges that influence losses at the farm level, a variety of other constraints such as lack of processing facilities, poor storage facilities and inadequate transport availability influence the production of livestock products (Hemme and Otte 2010, Mazumder, Kalita et al. 2014, Thomas, Zerbini et al. 2002) and the ability of small holders to market livestock products at premium prices. However, no comparable information exists in CDZ Myanmar. There is still a need to understand what factors are the main barriers in the development of livestock production in the CDZ of Myanmar.

A number of socio-economic factors affect livestock production (Annex 7). Women play a leading role in small-scale livestock production in developing countries such as Myanmar and South Africa (Fratkin 1989, Sinn, Ketzis et al. 1999, Vanhonacker, Verbeke et al. 2009). The feeding of livestock and the cleaning of livestock shelters are mainly conducted by women while men usually work to earn income outside the household (Henning, Pym et al. 2007, Jaitner, Sowe et al. 2001).

It is interesting to know from one study in Malawi that gender and experience in production and availability of grazing ground played major roles in decisions on herd size and milk production (Tebug, Kasulo et al. 2012). To increase herd sizes, sufficient space for livestock management is necessary. Small holders in developing countries sold out their land and acquired new large plots of land to develop larger livestock operations with advanced technology, sufficient feeding and drinking space, resting places, and movement areas for their livestock (Bellaver and Bellaver 1999, Estevez, Andersen et al. 2007, Gillette 2013).

Age of farmers has some effect on herd structure in livestock production. For example, in South Africa, younger farmers are more likely to prefer to increase their stocking density while older people prefer to maintain the current density (Boogaard, Oosting et al. 2006, Harper and Henson 2001, Vanhonacker, Verbeke et al. 2009). The main reason for increasing herd sizes is to increase economic returns and family income (Estevez, Andersen et al. 2007, Kunene and Fossey 2010).

Availability of family labour and time is a factor affecting livestock production (IGS Budisatria, HMJ Udo et al. 2007, Kristjanson, Krishna et al. 2004, Morand-Fehr and Boyazoglu 1999). The price of livestock is usually high at the time of festivals and other special occasions; for example, prices for small ruminants are high during the Moslem feast of sacrifice in Indonesia (Budisatria, Udo et al. 2008).

In South East Asia, small-scale farmers have limited opportunities to obtain good education (Steinfeld 2003). Poor awareness of livestock management leads to technical barriers for farmers to efficiently manage livestock (Chander, Bodapati et al. 2011, Kahan 2003, McDermott, Staal et al. 2010, Steinfeld 2003).

In Zimbabwe, Eastern Congo, and Indonesia, it was mentioned that financial barriers limit small-scale livestock producers investing into livestock production (IGS Budisatria, HMJ Udo et al. 2007, Chawatama, Mutisi et al. 2005, Horowitz and Little 1987, Maass, Katunga Musale et al. 2012, Steinfeld 2003). Often droughts result in price increases for grain, while price of livestock decreases (Blench and Marriage 1999).

For landless livestock farmers (in CDZ 55% households are landless) (Horowitz and Little 1987, JICA 2010, LIFT 2014), a drought period is the most stressful period as the availability of grass is scarce and they are unable to buy feed for cattle (Blench and Marriage 1999, Kahan 2003). In severe drought conditions, keeping vulnerable animals such as cattle is difficult and farmers might change their herd structure by replacing cattle with low price animals such as sheep and goats which are more resistant to heat (Blench and Marriage 1999, JICA 2010, Mulder and Sellen 1994). This might also be happening in the CDZ, but needs to be further researched.

Livestock production has some effects on public health. In one study in Indonesia, it was noted that livestock housing close to family quarters will more likely result in drinking water contamination (IGS Budisatria, HMJ Udo et al. 2007).

Limited information about the major constraints in livestock development in the CDZ is provided in the available literature.

2.5 Livestock diseases affecting small-scale livestock production systems in developing countries and in Myanmar

The World Organization for Animal Health (OIE) publishes a list of important livestock diseases that are threatening the global population growth by affecting food security, economic and social development and public health. According to OIE, the most important list A livestock diseases limiting livestock production due to mortalities, reduced performance and slow growth of animals, included Foot and Mouth Disease (FMD), Peste des petits ruminants, Lumpy skin disease, Bluetongue, African horse sickness, Vesicular stomatitis, Rinderpest, sheep and goat pox, contagious bovine pleuropneumonia, Rift Valley fever, Newcastle Disease (ND) and Highly Pathogenic Avian Influenza (HPAI) which were also reported in Myanmar (OIE 2018a, 2018d, Oo 2013, 2014).

Among these livestock disease, one of the OIE list A diseases, Foot and Mouth Disease (FMD), affects cloven hoof animals and has major impacts on international trading (Cocks, Robertson et al. 2012, Edwards 2003, OIE 2015, Oo 2010, Ozawa 1993) and FMD has been standing in the OIE list A for many years. There are seven strains of infectious agent for FMD (A, O, C, SAT1, SAT2, SAT3, Asia1) and the major clinical signs seen in the clinically infected animals include fever and blister-like sores on the tongue and lips, in the mouth, on the teats and between the hooves. This further leads to. causing severe production losses and weakening of the recovered animals, a price decrease in animals sold, a reduction of draught power, a reduction of manure production, and a reduction of reproductive ability as reported for Cambodia and Laos (Bellet, Vergne et al. 2012, Nampanya, Suon et al. 2012, OIE 2018c, Oo 2010, Perry, Gleeson et al. 2002). Even though FMD causes severe economic loss in Myanmar and Laos, some farmers rate this disease of low importance as the mortality rate is low compared to other infectious diseases (Oo 2010, Perry, Gleeson et al. 2002).

One of the infectious disease noted in avian industries and domestic poultry production is Newcastle Disease (ND), a contagious disease with a high mortality rate, caused by paramyxoviruses. The severe economic and socio-economic impact of Newcastle Disease (ND) was reported in Myanmar, Bangladesh, Pakistan, Indonesia, China and other South East Asia regions (Adi, Astawa et al. 2010, Biswas, Barua et al. 2009, Biswas, Uddin et al. 2008, Dutta, Islam et al. 2013, Henning, Morton et al. 2008, Henning, Pym et al. 2007, Kawamura, Nerome et al. 1987, Liang, Cao et al. 2002, Munir, Zohari et al. 2012, Qin, Tan et al. 2008, Siddique, Naeem et al. 2013, Zhang, Zhao et al. 2011). Newcastle disease (ND) has been notorious for its high mortality rate and causing loss of production. This disease can cause a number of clinical lesions including respiratory disease, but depression, nervous manifestations, or diarrhoea may be the predominant clinical form and one of the obvious clinical sign in poultry is twisted head and neck in chickens (OIE 2018a).

Even though the common livestock diseases such as FMD and ND have been highly reported in Myanmar, limited information is available on farmers' attitudes towards these diseases and the practice of preventive action in CDZ.

2.6 Methods to control and prevent the occurrence of diseases in small-scale livestock production systems in developing countries and in Myanmar

World population of both animals and humans has been threatened by a number of health problems including viral, bacterial and parasitic diseases. Especially in the developing countries such as Asia and Africa, both humans and animals have suffered from a number of health problems due to poor sanitation, lack of proper health management practice, lack of animal movement control, poor veterinary and health services, and poor biosecurity practice. The majority of these health problems result in poor productivity and quality of the products in livestock, lifelong disability and thereby lead to serious socio-economic problems. Due to the adverse effect of these health problems, the international health organizations of World Health Organization (WHO), Center for Disease Control and Prevention (CDC), and World Organization for Animal Health (OIE) promote practicing the standardized disease control programmes and methods which are effective and affordable intervention strategies, in both developed and developing countries.

Disease control is a management practice reducing the opportunities for infectious agents to get access or to spread to the hosts which further lead to reducing the risk of introduction, spread of infections and infestation within the population. Biosecurity is one of the key criteria which is widely recommended by OIE and FAO to reduce the risk of introduction of diseases (FAO 2007, OIE 2017b, 2018a). The major key considerations in biosecurity include isolation, traffic and human control, and sanitation which help to reduce the disease incursion and spread within the specific population. Isolation mean to the confinement of the population within a controlled environment by controlling the movement in and out of animals. Cleansing and disinfection is also an effective method to break the spread of diseases by practicing proper cleansing methods, waste management and using disinfectant to reduce exposure. The biosecurity methods for prevention and control of disease are formally measured by the Hazard Analysis Critical Control Point (HACCP) system, Good Manufacturing Practice (GMP) and Good Husbandry Practice (GHP). In addition, proper biosecurity is the critical issue for global livestock trading as the member countries of World Trade Organization (WTO) have to follow the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) according to WTO and OIE guidelines for global food security and safety purpose (OIE and WTO 1998, WTO 1994). Despite their important role in managing disease occurrence, currently there is limited information available on how any of these practices are perceived or used by farmers in the CDZ of Myanmar.

A variety of traditional medicines are used to treat animal diseases in Myanmar, although veterinary services are available (Personal communication with Kyaw Naing Oo and Win Myint Thein). This practice is similar to some African and West South Asian regions (Blench and Marriage 1999, Oo 2010). As in these African countries, government veterinarians (in Myanmar the township veterinary officers and blue cross workers) have the responsibility for animal health care (Catley and Walker 1997, LIFT 2014). In addition, traders and private veterinarians also provide animal treatments (Personal communication with Kyaw Naing Oo and Win Myint Thein) (Blench and Marriage 1999).

Ash and lime are used in some households in Bangladesh to control and prevent livestock diseases (Dutta, Islam et al. 2013). Vaccinations for FMD, BQ, HS and anthrax for cattle are organized by local veterinary officers and by local authorities in the village and village tract. ND vaccination had been conducted to some village chickens in the past (Personal communication with Dr. Kyaw Naing Oo and Dr. Win Myint Thein) (National Consultative Committee 2013).

Even though the Livestock Breeding and Veterinary Department (LBVD) implemented a surveillance system and reporting system for disease control (MOALI, FAO et al. 2018), the small-scale livestock producers have no close communication with governmental organizations except during severe outbreaks. In addition, LBVD plays a relatively minor role in extension and public awareness campaigns for promoting sustainable disease control practices by local farmers, and public communication by LBVD seems to be still weak (Programme) 2004). Small-scale livestock producers usually treat minor disease incidents by themselves. During drought periods, government and non-government organizations often provide aid for restocking and for emergency relief to livestock owners (Personal communication with Dr. Win Myint Thein) (ACIAR 2013, JICA 2010, 2015).

According to the standardized guidelines for the control of various diseases, the common ways of prevention and control include: quarantine of sick animal or newly introduced animals, slaughtering of infected animals, movement control, vaccination practice, control of biological and mechanical vectors, avoid contact with reservoirs, therapeutic drugs, prophylactic drugs, genetic improvement, grazing strategies, improving husbandry practice, minimal disease, education or public awareness, and disinfection (OIE 2017a, 2017b).

For developing countries like Myanmar, the practice of vaccination to improve the herd immunity and the immunity of the host is one of the effective control methods to prevent the diseases. Different types of vaccine have been produced for many different kinds of infectious agents such as virus, bacteria and some helminths. Vaccination practice in the real world is conducted based on the condition of disease (Lubroth, Rweyemamu et al. 2007).

In addition to the above methods, the improvement of husbandry practice and treating the sick animal by using therapeutic drugs or prophylactic drugs is also the major problem-solving method in the developing countries. Reducing the presence of an infected animal in the environment also helps to reduce the spread of infectious agents and thereby helps to control the disease within the population (OIE 2017b, 2018a).

Health problems are considered as one of the major factors causing negative impact on the world population of both animals and humans for many decades. According to the World Health Organization (WHO) and World Organization for Animal Health (OIE), the various kinds of diseases including zoonoses have been threatening the quality and longevity of both animals and humans (OIE 2018b, WHO 2018). In developing countries of Asia and Africa where the majority of people rely on agriculture, both livestock diseases and zoonoses are the main problem for the development of livestock production and improving the quality of farmers' lives.

Due to these reported negative impacts of health problems on livestock development, many countries try to minimize disease occurrence by implementing disease control programmes (Persson and Jendteg 1992). However, the major problem of high livestock mortality was reported as undefined diseases in many developing countries of both Asia and Africa which can be one of the main reasons restricting livestock production (Amenu, Markemann et al. 2013, Chawatama, Mutisi et al. 2005, Maass, Katunga Musale et al. 2012, McDermott, Staal et al. 2010, Steinfeld 2003, Thomas, Zerbini et al. 2002). Apart from these unknown factors, highly reported poor management practice in developing countries such as poor sanitary regulations, poor health management and inadequate veterinary services are other things to consider for occurrence of diseases which might also be associated with mortalities (Bellaver and Bellaver 1999, Chander, Bodapati et al. 2011, Chawatama, Mutisi et al. 2005, Homann, Van Rooyen et al. 2007, Maass, Katunga Musale et al. 2012, Mazumder, Kalita et al. 2014, Thomas, Zerbini et al. 2002). In addition, a lack of knowledge on disease prevention methods and biosecurity measures is another main concern for livestock development in these regions (Conan, Goutard et al. 2012). There might be further constraints such as a lack of successful infectious disease control programmes and vaccination programmes (Henning, Pym et al. 2007, McDermott, Staal et al. 2010), limited existing animal health and veterinary services (Mazumder, Kalita et al. 2014, McDermott, Staal et al. 2010) and limited or non-existing extension programmes (Henning, Pym et al. 2007, Maass, Katunga Musale et al. 2012, Mazumder, Kalita et al. 2014, McDermott, Staal et al. 2010).

Furthermore, a limited knowledge of good livestock management such as genetic selection, visual inspection, an appropriate health care system, feeding and housing system, is a barrier to establishing a better livestock environment. Poor genetic sources of livestock might also result in high production cost (Chander, Bodapati et al. 2011, Tebug, Kasulo et al. 2012, Thomas, Zerbini et al. 2002, Vercoe 1997), low quantity and quality of livestock products (Steinfeld 2003), low offspring output (Amenu, Markemann et al. 2013). We also have to consider that selection of the type and sex of animal and secondly, a large distance between housing and grazing areas could also contribute to livestock losses and act as constraints in livestock production (Wang and Macdonald 2006).

2.7 Zoonotic livestock-derived diseases in developing countries and in Myanmar

Both, the human and animal population have been threatened by a number of emerging and re-emerging zoonotic diseases over the last decade. The World Health Organization (WHO) estimated that approximately 75% of the infections in humans originate from animals – a process known as zoonotic infections (WHO 2011, 2014). Due to transport and globalization, zoonoses are able to spread quickly across the globe and became one of the major public health threats in both developed and developing countries. A number of different factors such as tourism, poor biosecurity practices, close contacts between animal and human, poor veterinary services, and poor accessibility to information about zoonoses resulted in a silent amplification of zoontoc diseases in developing countries (Cáceres 2009, Conan, Goutard et al. 2012, Irwin and Jefferies 2004, McLeod 2004).

According to the World Organization for Animal Health (OIE), some zoonotic diseases such as Anthrax, Brucellosis, Rabies, Japanese encephalitis, Q fever, Trichinella spp., tuberculosis, Salmonellosis, Avian influenza infection can have an impact on global population growth due to their negative impact on food security, public health and on the socio-economic status of people (OIE 2016, 2018a). Being a developing country, Myanmar also has to deal with a number of zoonotic diseases. Anthrax is a life-threatening disease not only for humans but also for livestock. Outbreak cases have been reported from Myanmar, Thailand, Bangladesh and India (Chakraborty, Khan et al. 2012, Kunanusont, Limpakarnjanarat et al. 1990, Lakshmi and Kumar 1992, Mondal and Yamage 2014, Narayan, Sreelakshmi et al. 2009, Oo 2013, Samad and Hoque 1986). In 2011, 771 fatal anthrax cases were reported in Myanmar (Oo 2013). Tuberculosis does most likely exist in Myanmar – there have been cases of tuberculosis in humans, but the source of infection could not be identified (Medlen, Hawley et al. 2015). According to the LBVD national laboratory, no positive tuberculosis test result were obtained from cattle and small ruminant samples submitted between 2011 and 2014, but it is assumed that the disease most likely exists in livestock in Myanmar (Oo 2013, 2014). According to LBVD, positive test results for Brucella pathogens were detected from samples submitted between 2011 and 2014 (Oo 2013, 2014). Highly pathogenic avian influenza (HPAI) is another zoonosis of importance for the Asia continent (OIE 2018a, 2018b, 2018d). Outbreaks of HPAI in Myanmar have been reported since 2011 (Oo 2013, 2014).

2.8 Livestock disease control infrastructure in Myanmar

The Livestock Breeding and Veterinary Department (LBVD) under the Ministry of Livestock, Fisheries and Rural Development is the major governmental organization that oversees animal production, trading, health care, disease control and livestock research in Myanmar. LBVD's objective is specified as to enhance livestock production by technology and services, in order to develop the national livestock sector; and to manage animal health care, disease control, activities of animal breeding and production in line with the Animal Health and Development Law (1993) (MLFRD 2015).

The responsibility for providing veterinary care in Myanmar lies with the central government and regional governments. Veterinary services in townships comprise of township veterinary officers and private veterinarians (both groups are usually graduates of the University of Veterinary Science (UVS), Yezin, Myanmar) and the para-veterinarian or blue cross workers who are informally trained by veterinary township officers (Personal communication with Dr. Kyaw Naing Oo).

In addition, some other national organizations such as the Myanmar Livestock Federation (MLF) (Personal communication with Dr. Win Naing Phone), or international organisations such as the Australian Centre for International Agriculture Research (ACIAR), the Food and Agriculture Organization (FAO), the World Organization for Animal Health (OIE), The Likelihood and Food Security Trust (LIFT) and others provide support to livestock development and disease control programmes in Myanmar and in the CDZ (ACIAR 2013, 2014, JICA 2010, LIFT 2014).

Veterinary research in Myanmar is largely driven by the objectives of the implementing government and non-government organizations. Past veterinary research projects in Myanmar focused on estimating the prevalence of livestock diseases, on the improvement of dairy production by cross-breeding, on the monitoring of vaccination programmes or on description of animal nutrition parameters (M. Aung 2011, Z.L Aung 2011, Henning, Khin et al. 2006, J Henning, J Morton et al. 2013, Henning, Pym et al. 2007, Htet 2011, JICA 2010, Kyin 2000, Maw 2011, Oo 2010, Win 2013, Wynn 2011).

Research projects conducted by LBVD and UVS had focused on outbreak investigations (e.g. Foot and Mouth Disease outbreaks), on the identification of factors that are associated with the occurrence of animal and zoonotic diseases (e.g. Newcastle Disease in village chickens and molecular characteristic of highly pathogenic avian influenza virus in Myanmar) and on exploring animal nutrition problems (e.g. measuring nutritional value of dry and organic matter in livestock feed) (M. Aung 2011, Z.L Aung 2011, Htet 2011, Linn 2011, Maw 2011, Mon 2011, Oo 2010, Win 2013, Wynn 2011).

As international organizations such as FAO (Devendra 1993, Devendra and Thomas 2002a, 2002b, Grimes 2002, Leibler, Otte et al. 2009, Ozawa 1993, Ramaswamy 1985, Rushton, Viscarra et al. 2011, Speedy 2003), USAID (Devendra and Thomas 2002b), the International Atomic Energy Agency (IAEA) (Ramaswamy 1985), the World Organization for Animal Health (OIE) (Cocks, Robertson et al. 2012, Edwards 2003, Wijaszka 2010, Wongsathapornchai, Salman et al. 2008), the Australian Centre for International Agriculture Research Centre (ACIAR) (ACIAR 2013), the Japan International Cooperation Agency (JICA)(JICA 2015) and the Korea International Cooperation Agency (KOICA) (Henning, Khin et al. 2006, Henning, Pym et al. 2007, JICA 2010, Kyin 2000, Maw 2011, van der Lee and de Jong 2014) also support veterinary research projects in Myanmar.

However, research publications describing the livestock production system, health management and livestock marketing network in Myanmar, especially in the CDZ, are very scarce.

2.9 Knowledge gaps identified in the literature

There is an eminent lack of information on livestock husbandry practices, nutrition, syndromic health problems, health management practice, the socio-economic status of local small-scale farmers, and factors influencing health problems, expense of livestock production and income generation through livestock production. In addition, the disease control being the critical issue for livestock development, there is a knowledge gap in the perception of local livestock farmers and traders on disease control practice for common livestock diseases (i.e. FMD and ND) and zoonoses.

We conducted different regression modelling approaches in this research project to understand the linkages, constraints and opportunities for current livestock production, health and livelihood of local livestock farmers in the CDZ of Myanmar. Path analysis modelling and multilevel mixed-effects generalized linear modelling approach were developed to identify factors affecting livestock disease and zoonoses control by livestock farmers and trading people. Additionally, social network analysis was applied to understand the livestock trading connectivity and density of local value chain actors including both farmers and trading people.

In our study, we aim to identify constraints and opportunities to improve the income of small-scale farmers through improved livestock husbandry practices and health management and to provide recommendations to prevent and control zoonotic and animal diseases under a one-health paradigm.

CHAPTER 3

GENERAL METHODOLOGY

3.1 Introduction

The overall research objective is to describe and quantify the current livestock health and production in the CDZ of Myanmar. To achieve this research aim, a series of cross-sectional studies were conducted to describe the livestock management and husbandry practices, to identify factors influencing livestock health, to summarize farmers' behaviours and awareness towards prevention of livestock and zoonotic diseases, and to describe the livestock trading network. As households in the CDZ typically own multiple livestock species, the research focuses on ownership of cattle, small ruminants and village chickens or any combinations of these.

A total of four research studies conducted, as follows:

Research study 1: Characteristics of livestock husbandry practices on small-scale, multispecies livestock rearing farms in Myanmar

Research study 2: Impact of husbandry and health management practices on summary measures for multispecies livestock rearing and on income generated from livestock farming in Myanmar

Research study 3: Factors influencing small-scale farmers' decisions to vaccinate their animals against common infectious livestock diseases

Research study 4: Perceptions of livestock value chain actors on the risk of acquiring zoonotic diseases from their livestock

3.2 Data collection

3.2.1 Study design

The cross-sectional studies involving small-scale farming households owning different livestock species and traders were conducted in the Central Dry Zone (CDZ) of Myanmar. The research was conducted between 2014-2015 in two administrative areas ('townships'), Myingyan and Meikhtila, of the CDZ. These two townships were identified as being representative for CDZ livestock holdings, production systems and the environment by a livestock research project, Dahat Pan project, (AH/2011/054) funded by Australian Centre for International Agriculture Research (ACIAR) (ACIAR 2013) (Figure 3.1).

The Dahat Pan project selected three representative villages in the Myingyan and Meikhtila townships and focussed on longitudinal data collection of husbandry practices and the health status of different livestock species and the implementation and evaluation of interventions to improve the nutritional status and reduce mortalities of livestock. Thus, the Dahat Pan project focussed on intensive data collection, including sampling and vaccinations of animals, body condition monitoring, feeding trials etc. while improving the skills and technical abilities of livestock farmers. The cross-sectional studies complemented the Dahat Pan project as it focused on a) a representative sample of all villages and trading sites within the selected townships and b) the impact of household and village level factors on syndromic health problems, husbandry, disease prevention practices, farmer's perceptions and trading practices.

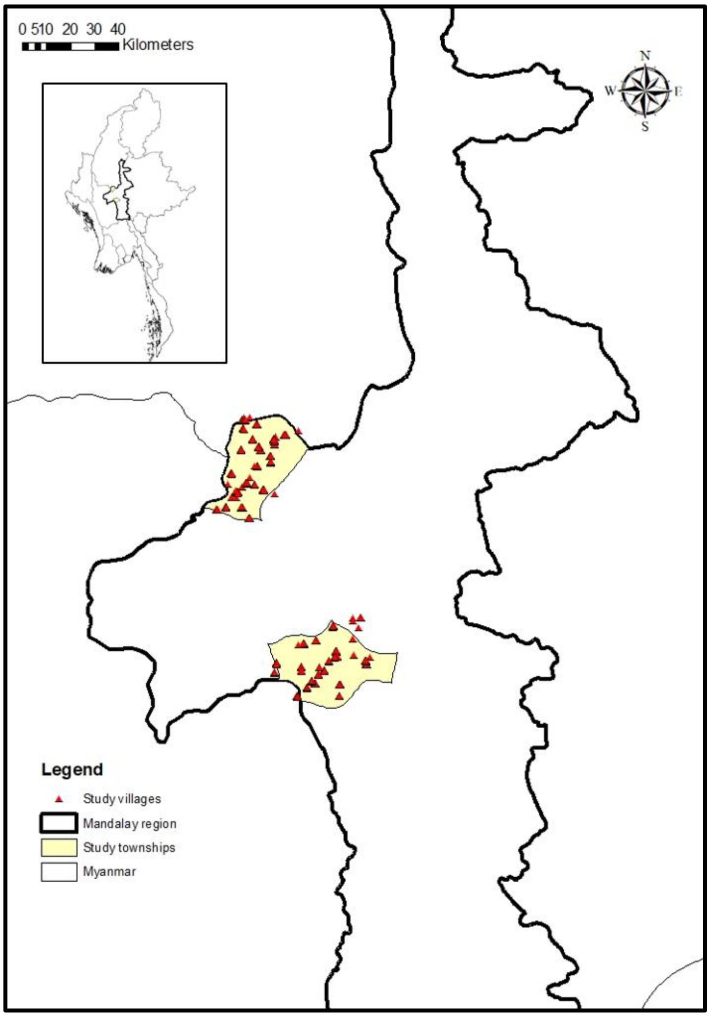
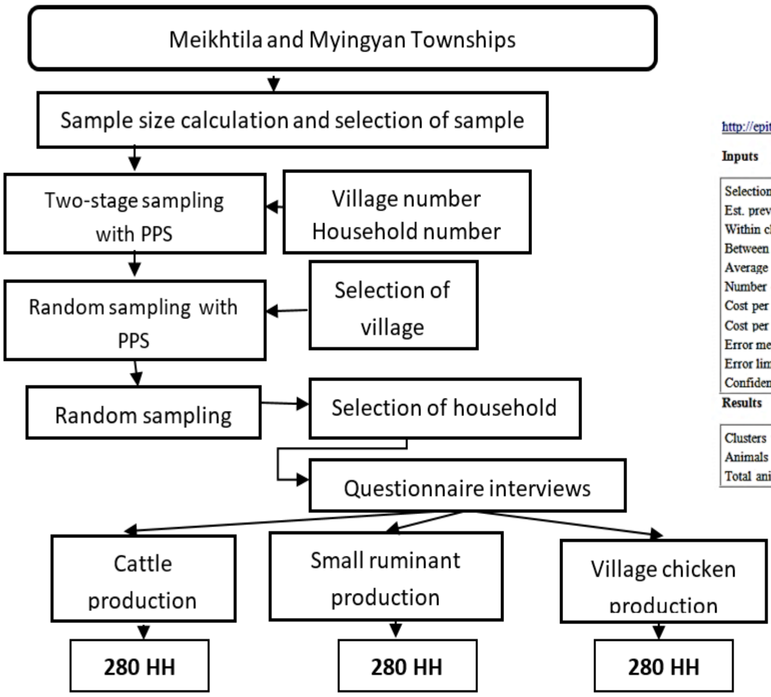


Figure 3.1 Map of Central Dry Zone of Myanmar within two townships (Meikhtila and Myingyan) where research on multispecies livestock rearing was conducted highlighted in yellow, red triangles representing studied areas

3.2.2 Sample size calculation and selection of sampling units

3.2.2.1 Farmers

A two-stage sampling approach was used, with villages ('clusters') and households comprising of the two sampling stages. The proportion of farm income generated from livestock production was used as the outcome of interest for the sample size calculations, conservatively assumed to be 50%, with within- and between-cluster variances of ±10% and ±2.5%, respectively. The low between-cluster variance reflected very similar ecological conditions resulting in similar income generation from livestock production across villages in the CDZ. Assuming that the proportion of farmers in a village deriving at least half of their income from livestock production was 0.7, a population of 400 villages per township and approximately 200 households per village (based on livestock statistics data compiled (LBVD 2014)), a precision of the estimate of ±5% with a 95% confidence interval, the estimated sample size was 20 households per village and 38 villages across the two townships. Lists of villages were provided by LBVD. In order to select villages, a probability-proportional-to-size sampling strategy was used (http://epitools.ausvet.com.au/content.php?page=2StagePrevalence1), giving larger villages a greater probability of being selected. A total of 40 villages were selected in each township (20 villages to be selected and 20 potential replacement villages). Within selected villages, lists of households for each of the three major livestock species (cattle, small ruminants and village chickens) were provided by village headmen. Selected villages were replaced if they had insufficient households with the three livestock species of interest or if farmers were not willing to participate in the study. Overall, seven households from each livestock ownership list were randomly selected, providing a total of 21 households per village. Sample size calculations and random sampling were performed using the Survey Toolbox modules Sample size for 2-stage prevalence survey, Random sampling from a sampling frame (http://epitools.ausvet.com.au/content.php? page=Random Sampling1) and Random sampling of animals, respectively (http://epitools.ausvet.com.au/content.php? page=RandomSampling2) (Sergeant 2014a) (Figure 3.2). A total of 20 cattle farmers, 45 small ruminant farmers, and 54 village chicken farmers refused to participate in the survey and replacement households were randomly selected from the sampling frame.



http://epitools.ausvet.com.au/content.php?page=2

Inputs

Selection Method	PPS Sampling
Est. prevalence	0.7
Within cluster variance	0.1
Between cluster variance	0.025
Average cluster size	200
Number of clusters	400
Cost per cluster	1000
Cost per animal	10
Error method	Fixed Width
Error limit	+/- 0.05
Confidence level	95%

Results

Clusters to sample	38
Animals to sample per village	20
Total animals to sample	760

Figure 3.2 Sampling framework for livestock farmer household survey in Meikhtila and Myingyan townships

3.2.2.2 Traders

Stakeholders involved in livestock marketing network were identified using various approaches: a) they were identified by farmers in the household survey by specifying the trader's phone number or/and living locations, b) they were identified on livestock markets and c) they were identified by asking interviewed traders about other traders they are knowing. The following marking locations were visited: two cattle markets, three bazaars, 10 village markets and 28 households where traders and middlemen were living. Stakeholders involved in livestock marketing network were classified as follows:

Middlemen: These are people involved in the trading network, who buy livestock (i.e. cattle or small ruminants or village chickens) from the farmers and sell them to traders or main collectors.

Branch collectors: These are people involved in the trading network, who purchase livestock in the villages with the money provided to them by the main collector/traders. The branch collectors are employees of the main collectors.

Main collector/Traders: These are people involved in the trading network, who buy the livestock from the middlemen or who employ the branch collectors. This group of people keep and trade a large number of animals and invest a large amount of money to set up the trading hubs.

Hawkers: These people are selling goods, typically advertising them by shouting. They sell livestock products such as meat (not live animals), vegetables and food in the markets or in villages, to which they travel by motorbike or bicycle.

3.2.3 Farm profiles

The questionnaire used in the farm level survey can be found in Annex 8.

3.2.3.1 Demographic information and farmers' perceptions

Demographic information including the age, gender and the role within a household were collected from farmers. In addition, information on the duration of rearing livestock was collected to understand the experience of farmers with different livestock species.

A number of questions from the survey identified the perceptions of farmers about common livestock diseases. Firstly, farmers' knowledge of the diseases (Foot and Mouth Disease, and Newcastle Disease) was identified by asking general information about the clinical symptoms associated with these diseases. Then, the perception of farmers on the impact of diseases on the trade and marketing of animals was explored. Furthermore, we explored the factors that influenced a farmer's decision to conduct vaccinations against FMD and ND, such as source of information on vaccination, barriers to practicing vaccination, perception on the effectiveness of vaccination, and finally the willingness of farmers to practise vaccination of their animals.

Similar questions were asked about farmer's perceptions on the prevention of zoonotic diseases (i.e. tuberculosis, brucellosis, anthrax and highly pathogenic avian influenza). We explored the farmers' level of knowledge about common zoonoses such as the clinical symptoms associated with the zoonotic diseases and the perceptions about the zoonotic risk from different livestock species. In addition, perceptions on the severity of diseases transmitted from livestock species were explored as sources of information about zoonoses, barriers to conducting zoonoses control, methods used to prevent zoonotic disease, and farmers' confidence in the success of zoonotic disease prevention practices.

3.2.3.2 Livestock management

To understand the current husbandry practices in the CDZ, we collected the location of surveyed villages and details of farm management practices across different livestock enterprises. The number of heads of livestock reared in each household and the purpose of rearing them was collected to estimate the average herd/flock size of livestock in small-scale farms. Information was collected on breeding methods used, castration and weaning practices, husbandry including provision of shelters and location of shelter. In addition, feeding management, such type of feedstuff provided for each livestock species, grazing practices, provision of supplementary feeds, provision of water and the source of water and seasonal variation in feeding across different livestock species were explored.

3.2.3.3 Livestock health problems and their management

The occurrences of clinical signs in each livestock species over the 12 months preceding the interview were summarized and grouped in the following body system-related categories within the farm regarding age and sex of the animal: physical problems (e.g. sore or abnormal hoof, foot or leg causing abnormal movement in ruminants; and twisted head and neck in chickens), respiratory problem (e.g. coughing, sneezing, discharge from the nose or other breathing problems), digestive problems (e.g. constipation or straining to defecate, or pain in the belly, diarrhoea), nervous problems (e.g. blindness, circling, abnormal behaviour), skin problems (e.g. loss of hair/wool/feather, abnormal colour or appearance of skin, such as scabs on surface), reproductive problems (e.g. abortions, offspring born dead, discharge from vulva in ruminants and poor egg quality; abnormal shape of egg; softened egg shell in chickens), urinary problems (e.g. difficulty/straining to urinate, abnormal urine colour in ruminants), sudden death (Please see questionnaire for details). This information might help us to understand the major health problems occurring in the CDZ, help to develop more detailed investigation on common diseases, and thereby develop better control programmes relevant to the local situation.

Information on health management was collected covering four sectors: treatment (including type of treatment, the source of advice on treatment and the person administering treatment), vaccination practice (including practice of vaccination, type of vaccine used, person administering vaccination), activities for reducing disease transmission (such as quarantining sick animals, minimizing contact with sick animals, limited entry of visitors), and sanitation practices (such as general cleansing, removal of faeces, disinfection).

3.2.3.4 Livestock sale prices

Livestock sale prices for different livestock species were collected stratified by age, sex, and season to identify factors affecting the variation of market values in livestock trading.

3.2.4 Traders profiles

The questionnaire used in the interview of stakeholders can be found in in Annex 9.

3.2.4.1 Demographic information and trader's perceptions

Geographical details of trading sites including the name of the region, district, township, village, livestock market and GPS coordinates were collected. We collected trading information from different groups of stakeholders involved in livestock trading, including traders, middlemen, branch collectors and hawkers. The questions used were varied depending on the role of stakeholders.

Demographic information collected included age, gender, role of interviewee, the type of operation (i.e. full-time or part time), type of trading (export or domestic trading), experience of interviewee in trading practice, and type of animal traded (i.e. live or dead animal).

A number of questions from the survey identified the perception of trading people (i.e. hawkers, middlemen, branch collectors, and traders) on common reported zoonoses control (i.e. tuberculosis, brucellosis, anthrax and highly pathogenic avian influenza). We explored their level of knowledge about common zoonoses such as the clinical symptoms associated with the zoonotic diseases and the perceptions about the zoonotic risk from different livestock species. In addition, perceptions on the severity of diseases transmitted from livestock species were explored sources of information as well about zoonoses, barriers to conducting zoonoses control, methods used to prevent zoonotic disease, and farmers' confidence in the success of zoonotic disease prevention practices.

3.2.4.2 Livestock trading practice and trading network

Understanding the trading network across different livestock species and different locations is crucial for developing strategies for disease control and promoting trading availability. Thus, in our study, we explored the trading network by collecting data on the name of traders involved in trading, the name of the agent conducting the sale of the animals, the number of animals traded per trading, frequency of trades per month, and trading sites.

As trading and animal movement are major factors favouring disease transmission between regions, identification of health problems and management practice while holding the animals plays a critical role for evolving a regional disease control strategy. Therefore, we explored the health problems seen while holding the animals, and health management practices such as provision of treatment, type of treatment provided to the sick animal, duration of keeping the animal, source of advice on treatment, sanitation practice, minimizing the contact with sick animal, segregation of the sick animal, general cleansing practice and disinfection.

3.3 Research plans

Objective 1 To describe animal husbandry practices and livestock ownership patterns on small-scale farms in the CDZ of Myanmar

Study design: A cross-sectional study was conducted among small-scale farming households owning different livestock species in two administrative areas (‘townships’), Myingyan and Meikhtila, of the CDZ of Myanmar. A two-stage sampling approach was used to identify villages and households in the survey, with village being the primary and households being the secondary sampling units. A questionnaire was used to collect information on the livestock herd/flock structure, husbandry practices, health problems and biosecurity measures. Seven households of each livestock type (cattle, small ruminants and village chickens) were visited in each village. The study was conducted across 40 villages and a total of 613 farmers rearing different livestock species were interviewed (Figure 3.2).

Data analysis: Survey design approaches were used to describe and compare husbandry practices and livestock health problems between different livestock owning households. Survey-design based multinomial and ordinal regression modelling approaches were used to identify factors influencing herd/flock sizes and purposes of rearing in small-scale households (Figure 3.3).

Objective 2 To identify production, health and livelihood parameters that can be compared between different livestock species and to analyse associations between these production and health parameters and farm management practices in the CDZ of Myanmar

Study design: The study design is outlined in Chapter 4.

Data analysis: Livestock health and livelihood parameters that can be compared between different livestock species were developed (livestock health categories, biosecurity and livestock disease prevention index and income generated from livestock sales) and survey-design based binomial and ordinal regression modelling approaches were used to identify factors influencing these livestock health and livelihood parameters across different livestock species (Figure 3.3).

Objective 3 To describe small-scale farmers' attitudes and behaviours towards implementing vaccinations against FMD and ND in the CDZ of Myanmar

Study design: The study design is outlined in chapter 4. Farmers were also questioned about their attitudes and behaviours towards livestock diseases, cross-species disease transmission and disease prevention approaches.

Data analysis: Using a modified health belief framework, causal diagrams were developed and path analysis was used to explore attitudes and behaviours of small scale farmers to implement vaccinations against FMD and ND across different livestock species (Figure 3.3).

Objective 4 To describe the attitudes and awareness of small-scale farmers and livestock traders in the CDZ of Myanmar towards zoonotic disease prevention

Study design: The study design is outlined in chapter 4. Farmers were also interviewed about their attitudes and awareness towards zoonoses transmission. In addition, a cross-sectional survey was conducted among stakeholders involved in the trade of different livestock species in two administrative areas ('townships'), Myingyan and Meikhtila, in the CDZ of Myanmar. Different groups of value chain actors (i.e. farmers, hawkers, middlemen and traders) associated with livestock trading were interviewed using a questionnaire to explore their attitudes towards zoonoses and their social trading network connectivity (Scott 2012).

Data analysis: Social network analysis was used to identify the network density of value chain actors and the effect of trading density on the perceived threat of zoonoses by value chain actors. Multilevel mixed effect generalized linear binomial modelling was used to identify the attitudes of livestock value chain actors towards zoonotic livestock diseases occurring on farms (Figure 3.3).

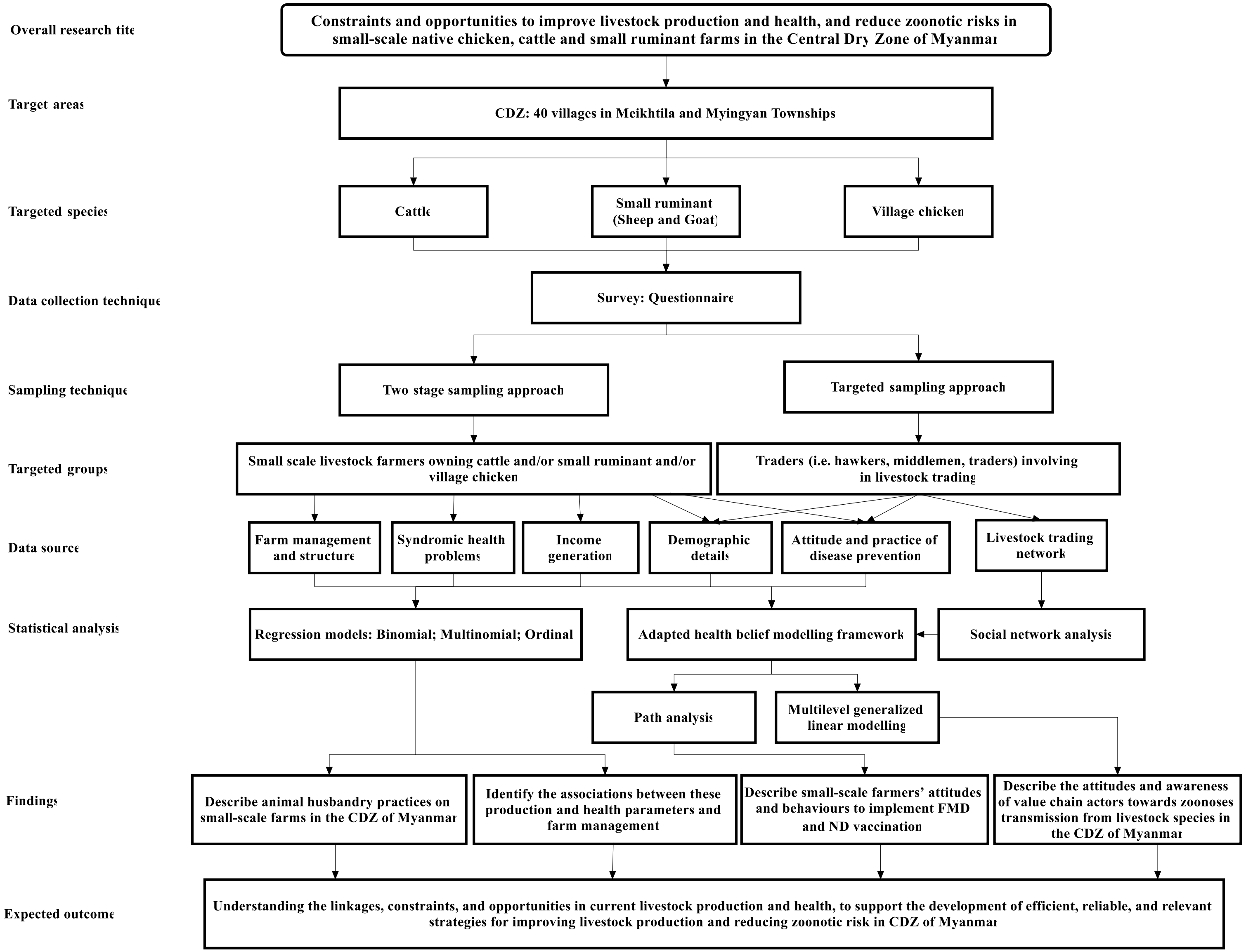


Figure 3.3 Flow chart for data collection

CHAPTER 4

CHARACTERISTICS OF LIVESTOCK HUSBANDRY PRACTICES ON SMALL-SCALE, MULTISPECIES LIVESTOCK REARING FARMS IN MYANMAR

4.1 Context

The Central Dry Zone (CDZ) is one of the poorest regions in Myanmar and like other regions of the country, the majority of people are farmers who practise crop production. The people in this area are faced with multiple environmental and climatic constraints such as high temperatures and scarcity of water. Due to these severe circumstances, people in this area rely heavily on livestock production to provide additional income for maintaining their livelihoods. However, low productivity of livestock is a major constraint for small-scale livestock farmers in the CDZ. To understand low productivity impediments, we have to understand livestock husbandry practices and herd and flock structures.

In this chapter (Research study 1), we identify types of livestock species reared within the same household, describe management practices and herd or flock structure. We then further investigate the association between management practices and herd/flock sizes and the different purposes of rearing livestock in the CDZ of Myanmar.

The findings from this research study are significant in a number of ways: (i) they provide an overview of livestock production in the CDZ of Myanmar; (ii) they highlight major husbandry factors both promoting or decreasing herd or flock size, and impact the purpose of rearing of livestock. Overall, we provide important baseline data for the development of appropriate intervention strategies in multispecies livestock owning households to overcome constraints that limit herd/flock sizes.

4.2 Abstract

The Central Dry Zone (CDZ) represents the area with the highest density of small scale livestock farmers in Myanmar. In this study we describe and quantify ownership patterns for various livestock species and characterise management and husbandry practices of small-scale farmers. In addition, we identify the husbandry factors associated with selected outcome indicators, such as ‘herd or flock size’ and ‘purpose of rearing’. A total of 613 livestock farmers in 40 villages were interviewed. Multispecies rearing was common with 51.7% of farmers rearing more than one livestock species. Rearing animals to be sold as adults for slaughter (meat production) was more common for small ruminants (98.1%) and chickens (99.8%) compared to cattle (69.8%). Larger cattle herds were more likely to practise grazing (p<0.001) and to employ labour from outside the household to manage cattle than medium or small herds (p=0.03). Patterns of grazing differed significantly between seasons (p<0.01) for cattle, but not for small ruminants, while patterns of scavenging by chickens did not vary seasonally. Inbreeding may be common in the small ruminant industry whereas outbreeding was a highly reported breeding method in cattle farms. Overall, multispecies rearing and species-specific husbandry practices were used to raise livestock under harsh environmental conditions. Our results reveal that herd/flock size, and purpose of rearing across different livestock species were significantly associated with feeding and housing practices and experience of farmers.

Keywords: Livestock, husbandry practice, multispecies, herd size, purpose

4.3 Introduction

Typically, descriptions of livestock production systems concentrate on one species of animal, although households in developing countries might keep multiple species and interrelationships in the management are likely to exist. In addition, livestock production in developing countries is often constrained by poor husbandry, inadequate housing, and poor breeding, health and biosecurity practices (Conan, Ponsich et al. 2013, Gillette 2013, Homann, Van Rooyen et al. 2007, Nampanya, Suon et al. 2012). Thus, in resource poor households that keep multiple livestock species, investments into feeding and housing need to be spread across various livestock species. It has been shown that farmers' income is largely influenced by herd size (Bailey, Hardin et al. 1997, Maltsoglou and Rapsomanikis 2005, McPeak 2004, Oleggini, Ely et al. 2001) and understanding factors that impact on herd size, in particular in multispecies households, is critical for rural livestock development (Kaimba, Njehia et al. 2011, Loibooki, Hofer et al. 2002). In addition, some livestock species are raised predominantly for sale, while others are more important for home consumption or to support other agriculture activities such as the use of cattle for draught power (Alam 1997, Kristjanson, Krishna et al. 2004, Moll 2005, Yamamoto 2004). Thus, understanding husbandry factors that influence the multiple purposes of livestock rearing is essential in order to work with livestock farmers on improvement of livestock production.

Unfortunately, little is known about livestock production in Myanmar, despite its great importance in Southeast Asia: approximately 16 million cattle, 7.7 million sheep and goats, and 270 million poultry were kept in Myanmar in 2015-16 (LBVD, 2014). Livestock in Myanmar is mainly reared on 'backyard farms', with feeding provided in traditional ways such as grazing common in fallow areas within and around villages or scavenging in the village environment and utilizing standing crop residues and by-products (Devendra and Thomas 2002a, 2002b, Devendra, Thomas et al. 1997, Henning, Pym et al. 2007, Oo 2010). The Central Dry Zone (CDZ) is a major hub for crop and livestock production with almost 50% of Myanmar's livestock population being reared in this area. This region supports 10 million people whose livelihoods depend on small-scale, dry-land agriculture, but it is also one of the poorest regions of Myanmar. Even though livestock production is considered to be a major income source for farmers in the CDZ, there is an eminent lack of information on livestock husbandry practices, nutrition, animal health problems, the socio-economic impact of livestock production and the current trading system.

In this study, we describe ownership patterns for various livestock species and characterise management and husbandry practices of small-scale farmers. We then select 'herd or flock size' as a measure describing the 'wealth' of farmers, but also reflecting the success of livestock production and identify factors of management and husbandry practices impacting on establishing herd or flock sizes. We also explore factors that impact on 'purposes of livestock rearing' because it describes the diversity of benefits that can be derived from livestock rearing.

4.4 Materials and Methods

4.4.1 Livestock husbandry questionnaire and data collection

The ethical approval for conducting the interviews with farmers was provided by the University of Queensland Human Research Ethics Committee (approval number #2014001425). A questionnaire was used to collect demographic details of farmers, information on herd structure, husbandry practices, and purpose of rearing. The questionnaire was developed in English and translated into the local language (Myanmar/Burmese). The questionnaire was piloted in six households owning multiple livestock species (cattle, goats and chickens) across two villages—one relatively poorer and one more affluent—in Meikhtila Township. After the pilot testing, a total number of 32 questions were modified and removed. Questions on home asset scores and feeding and housing were adjusted to be more relevant to the local conditions and to improve farmers' understanding of the questions. The final questionnaire had 34 questions for each livestock ownership groups, and the average duration of an interview was approximately one hour. According to the sample size calculation, total of 613 livestock farmers in 40 villages were interviewed. The survey was conducted from November 2014 to January 2015. The interviews were conducted by seven enumerators, comprising of Myanmar University of Veterinary Science postgraduate students and Livestock, Breeding and Veterinary Department (LBVD) staff. All enumerators were trained in the survey and interviewing techniques before the survey commenced (Chapter 3).

4.4.2 Categorization of variables

The number of animals kept per herd or flock was examined by tercile analysis, and the 33rd, 66th, 100th percentile was used to describe herd/flock sizes. Herds/flocks were classified into three sizes (small, medium, large), corresponding to these terciles for each livestock species: cattle herds - small (1-3 head), medium (4-6) and large (>6); small ruminants herds -

small (1-20), medium (21-40) and large (>40); and village chicken flocks - small (1-7), medium (8-14) and large (>14).

Purposes of cattle rearing were specified by farmers as ‘meat production (i.e. sale of adult animals for slaughter)’, ‘milk production’, ‘draught power’, ‘breeding and sale of offspring’ and ‘manure used for fertilizer’. Cattle rearing for ‘meat production’, ‘breeding’ and/or ‘milk production’ was combined into the category of ‘cash commodity’; cattle rearing for ‘draught power’ and ‘manure for fertilizer’ into the category ‘agriculture focus’ livestock rearing; and the combination of any these two categories was regarded as ‘multipurpose' cattle rearing. As chickens and chicken products (eggs) and small ruminants and their products (milk) were only used by farmers for sale and home consumption, we were not able to categorize purposes of livestock production for these two livestock species into separate categories.

4.4.3 Statistical analysis

We considered seven different types of livestock ownership: rearing either cattle, small ruminants or village chickens alone, rearing combinations of two livestock species or rearing all three livestock species together.

Data checking and validation was conducted by using NVivo Pro 11. Data were analysed using survey design commands in Stata 14.0 (Stata Statistical Software, College Station, Stata Corporation, 2014) to account for the two-stage study design, with sampling weights, sampling strata (townships) and clustering effects (villages) specified beforehand (Deaton 1997, Nathan and Holt 1980). The primary sampling units (PSUs) were villages within the townships, and the secondary sampling units (SSUs) were households within these villages. Sampling weights for the household and village level represented the inverse of the probability of being sampled (StataCorp LP 2014). Taylor linearization was used for variance estimation (VCE) (Cochran 1977, Wolter 2007), with a finite population correction (FPC) used for each sampling level by specifying the total number of villages and the total number of households. Two different sampling weights were used for the household and village level, representing the reverse of the probability of being sampled. The PSUs (villages) were also stratified into two strata (townships), assuming decreasing variability as sampled villages are more homogenous within the strata than between the strata (Heeringa, West et al. 2010, Levy and Lemeshow 2013, Skinner, Holt et al. 1989). Finite population corrections (FPC) were applied for each level, representing the number of total villages and households in the studied areas. This allowed accounting for the reduction in variance by comparing sampling without population replacement from a finite population with sampling with replacement from the same population (Cochran 1977).

The proportion of farmers having different herd/flock sizes categories (small, medium, large) and the proportion of farmers conducting different management practices (e.g. housing, feeding and breeding practices) was compared between livestock ownership groups using the Pearson $\chi 2$ Statistics, which was converted into F-statistics accounting for the survey design (Koch, Freeman Jr et al. 1975, Rao and Scott 1984). In addition, the proportion of farmers conducting seasonal feeding for each livestock species was compared using the survey-design converted F-statistic.

To identify factors that influence herd/flock size (low-medium-high) and the purpose of livestock rearing ordinal logistic regression and multinomial logistic regression models were developed for each livestock enterprise (cattle, small ruminants and chickens) (Figure 4.1). The proportional odds ratio assumption for the use of ordinal regression was assessed using the likelihood ratio test (-omodel- command in STATA) and the Brant test (-brant- command in STATA) (Agresti and Kateri 2011, Long and Freese 2006, Paxton 1999, Sloane and Morgan 1996). A non-significant result would indicate that parallel regression or proportional odds assumption is not violated (IRDE 2016). Similarly, nominal regression was used to identify livestock management practices that were associated with purpose of cattle rearing.

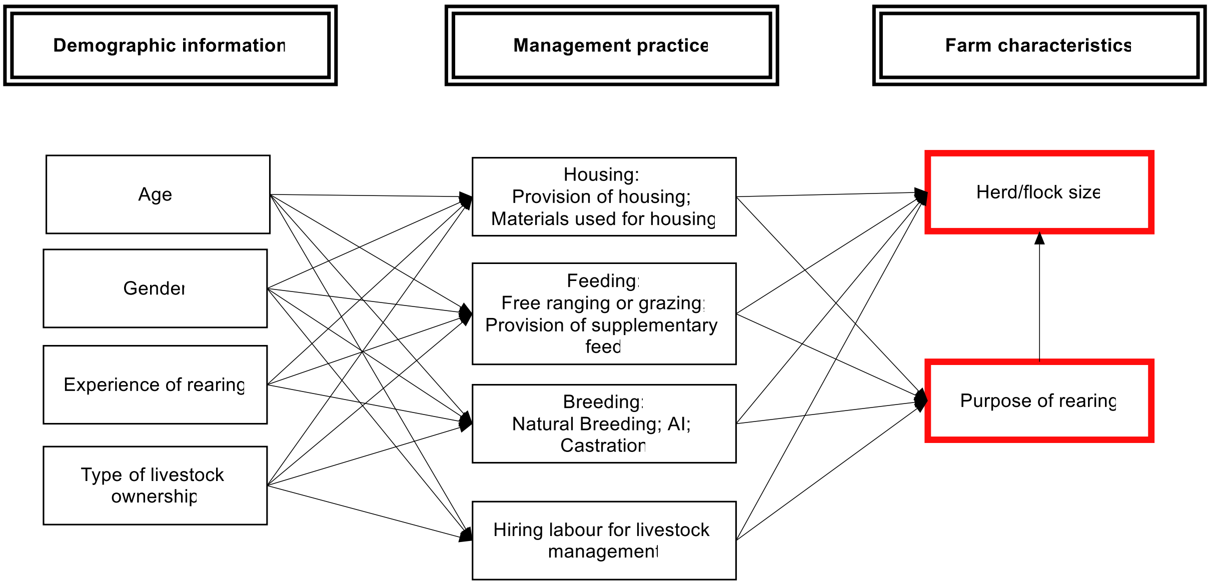


Figure 4.1 Hypothesized causal diagram on the impact of management practices and demographic information on herd/flock sizes and the purpose of rearing of livestock in the CDZ of Myanmar

Management factors significant at p<0.05 in the univariable analyses were included in the multivariable analyses in an initial forward selection and then backward elimination building procedure until all variables were significant at p<0.05. The Wald test was used to assess the joint significance of variables with more than 2 levels. The final, best-fitting model was selected as the one with the lowest Akaike Information Criterion (AIC).

4.5 Results

4.5.1 Dataset for analysis

Our aim was to collect data from seven households owning each of the three-livestock species in each of the 40 villages, representing 280 households for each species and 840 households altogether. However, many of the households selected from the sampling frame of cattle, small ruminant or village chicken owners, also kept other livestock species, and we also collected data for these additional species in the same household. As a result, fewer individual households were surveyed, with a total 613 household owners being interviewed, with cattle being raised in 382, small ruminants in 303, and village chickens in 327 households.

Men comprised 49.8% of the interviewees, and 50.2% were women. The mean age of the respondents was 47 (range 12-84) years.

62.3% of survey households owned cattle, followed by village chickens (53.3% of 613 households) and small ruminants (49.4% of 613 households). Mixed livestock rearing was common, with 311 (51.7% of 613 households) households rearing more than one livestock species (Figure 4.2). Of the 613 households, 19.6% of households had cattle only, 18.9% of households kept cattle and village chickens, 16.8% of households raised small ruminants only, 15.5% of households raised cattle, small ruminants, and village chickens together, 12.2% of households had village chickens only, 9.2% of households had cattle and small ruminants and 7.8% of households raised small ruminants and village chickens.

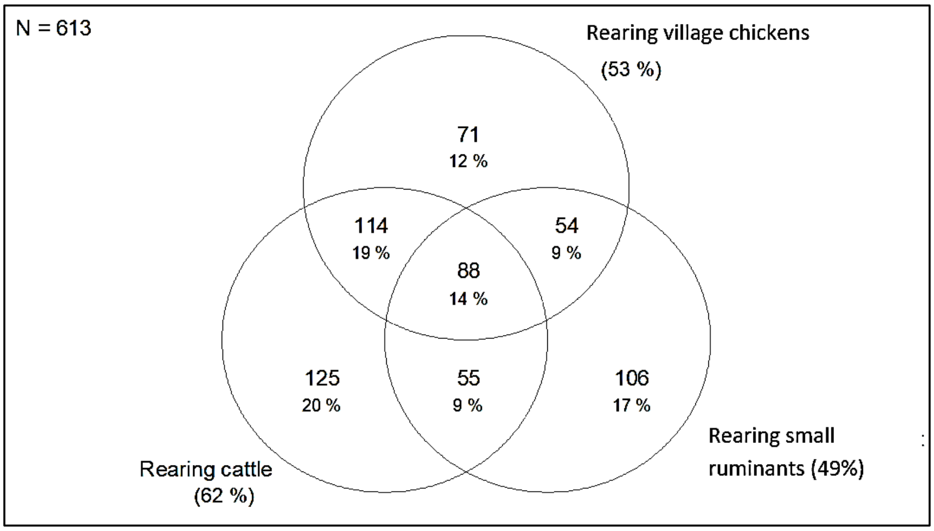


Figure 4.2 Proportion of farmers raising single species or combinations of livestock species in the CDZ of Myanmar (Cattle farmers: 382; Small ruminant farmers: 303; Village chicken farmers: 327)

Approximately three-quarters of the cattle and two-thirds of village chicken owners raised these species for more than 10 years, while the majority of small ruminant farmers (in particular sheep farmers) had less than 5 years' experience (Table 4.1).

Table 4.1 Experience of farmers raising livestock species in the CDZ of Myanmar

Species	Total number (N)	Proportion of farmers (Percentage with 95% CI)		
		<5 years	5-10 years	>10 years
Cattle	382	9.2 (6.4-13.2)	12.2 (8.1-18.0)	78.6 (72.8-83.4)
Sheep	303	87.2 (77.9-92.9)	5.2 (2.4-10.9)	7.7 (4.1-13.9)
Goats	303	51.2 (43.1-59.2)	19.6 (14.5-25.9)	29.3 (22.0-37.7)
Village chickens	327	23.9 (17.8-31.2)	10.6 (6.8-16.3)	65.5 (57.8-72.4)

4.5.2 Purposes of raising livestock

Livestock species were reared for different purposes. The majority of cattle farmers conducted cattle raising for multiple purposes (50.8%), followed by raising them only for draught power for crop production (33.5%), while rearing cattle for sale only was less common (15.7%). Manure from cattle was used by 56.7% of cattle-rearing households as fertilizer. Breeding small ruminants for the sale of offspring (88.1% of 303 small ruminant farmers) was more common than for cattle (74.2% of 382 cattle farmers). About one-third of households kept cattle (31.6%) or small ruminants (28.6%) for milk production. Cattle and small ruminants were not raised for home consumption. Rearing animals to be sold as adults for slaughter (meat production) was more common for small ruminants (98.1%) and chickens (99.8%) compared to cattle (69.8%). Village chickens were predominately raised for the cash sale of live birds (77.2% of 327 households), followed by home consumption (22.6%) and cockfighting (0.2%).

4.5.3 Herd or flock size

Herd/flock sizes varied across different livestock ownership categories as shown in Figure 4.3. The median herd size for cattle was 4 animals (IQR: 2-7), comprising of one male calf (range 1-5), one female calf (range 1-10), one cow (range 1-30) and one adult male (range 1-23). For small ruminants, the median size was 30 (IQR: 15-41), comprising of three (range 1-30) male offspring, four (range 1-30) female offspring, 17 (range 1-65) adult females and two (range 1-50) adult males. The median village chicken flock size was 10 (IQR: 5-18), comprising seven (range 1-400) chicks; two (range 1-30) hens and one (range 1-17) rooster. There was no significant difference in the proportion of households with 'Small, 'Medium' or 'Large' herds/flocks of cattle, small ruminants or village chickens across the different livestock ownership groups (p = 0.34, 0.51 and 0.79 for cattle, small ruminants and village chicken ownership groups, respectively (Table 4.2).

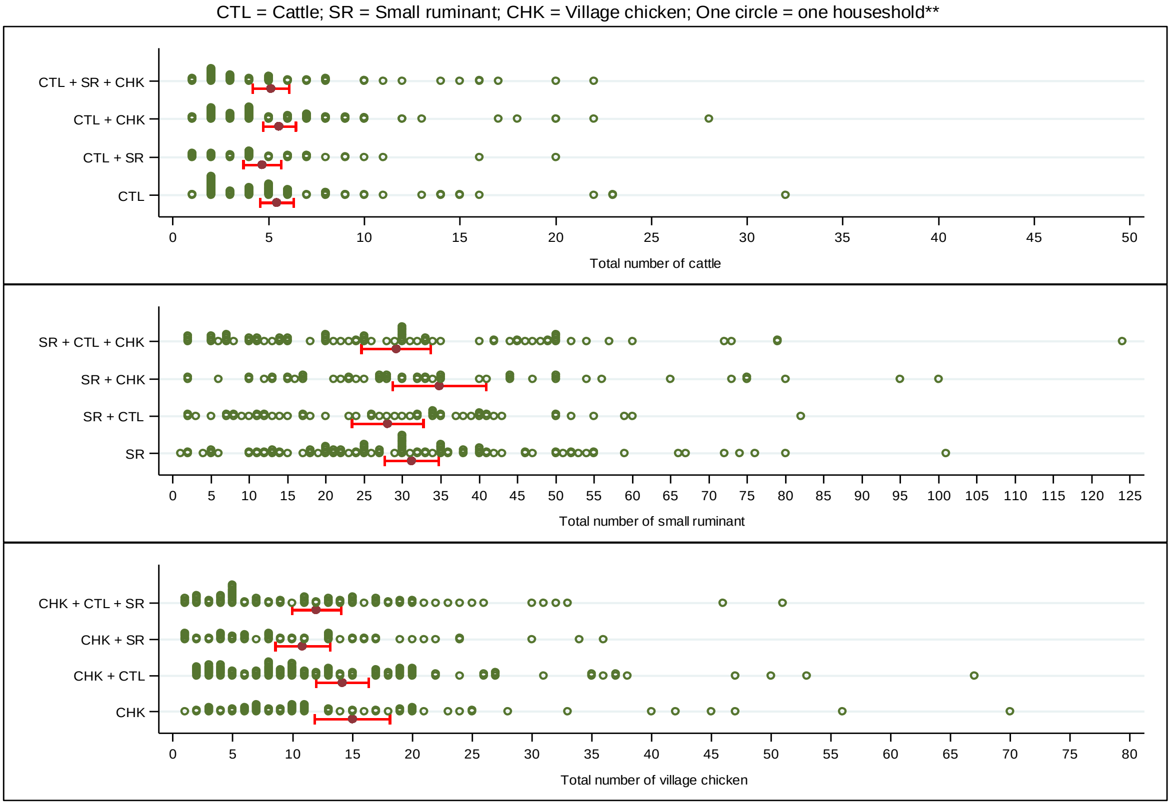


Figure 4.3 Distribution of cattle (CTL), small ruminants (SR) and village chickens (CHK) herd and flock sizes by livestock-ownership groups in the CDZ of Myanmar. Red horizontal bar indicates the mean herd/flock size with its 95% confidence interval

Table 4.2 Husbandry practices conducted by farmers owning cattle, small ruminants or village chickens singly or in combination with other species

Type of livestock enterprise	Provision of shelter (%)	Practise grazing (%)	Provision of any supplementary feed at home (%)	Herd/flock size			
				Small	Medium	Large	Median
Households owning cattle singly or with other livestock species							
CTL only (N = 125)	91.4%	71.6%	90.8%	38.3%	39.4%	22.3%	4
+ SR (N = 55)	74.2%	81.3%	71.4%	38.5%	38.7%	22.9%	4
+ CHK (N = 114)	77.6%	78.5%	84.6%	37.3%	29.8%	32.9%	4
+ SR + CHK (N = 88)	79.6%	77.0%	83.0%	53.5%	23.1%	23.3%	3.5
Households owning small ruminant singly or with other livestock species							
SR only (N = 106)	96.1%*[a]	98.8%	14.5%	24.0%	50.2%	25.8%	30
+ CTL (N = 55)	87.35%*[a]	97.1%	10.2%	35.4%	42.0%	22.6%	29
+ CHK (N = 54)	97.6%*[a]	0.0%	10.4%	20.3%	45.7%	34.0%	30
+ CTL + CHK (N = 88)	89.8%*[a]	97.7%	14.5%	33.9%	37.7%	28.4%	26
Households owning village chickens singly or with other livestock species							
CHK only (N = 71)	10.0%	94.1%	98.1%	32.6%	31.2%	36.2%	11
+ CTL (N = 114)	10.6%	88.7%	92.7%	32.3%	36.7%	31.0%	10
+ SR (N = 54)	19.3%	90.7%	98.4%	32.2%	34.1%	33.7%	9
+ CTL + SR (N = 88)	12.8%	82.7%	98.5%	44.0%	24.5%	31.5%	11

*CTL = Cattle; SR = Small ruminants; CHK = Village chickens

*: $p<0.05$; a: F-statistics = 2.7 (Comparison of provision of shelter across different livestock enterprises)

4.5.4 Livestock husbandry characteristics

Raising cattle, small ruminants or village chickens alone, with one other livestock species or all three-livestock species together did not influence their nutritional management (i.e. grazing practices, provision of supplementary feed and water). Similarly, grazing was common for both cattle (~70% of 382) and small ruminants (~90% of 303), but provision of cut and carry grass was more frequently conducted for cattle (~50%) compared to small ruminants (~2%). Patterns of cattle grazing differed significantly between seasons ($p<0.01$). Seventy-four percent of cattle herds were taken out for grazing in the rainy season (June-October) and winter (November-February), whereas only 62.0% of herds grazed in the summer months (March-May; Table 4.3). Providing supplementary feed to cattle was more common (>50% of HH) during summer and then decreased (<50%) in the winter and rainy seasons. In contrast, no seasonal differences were observed for small ruminant grazing, with approximately 98.0% of small ruminant herds grazing in summer, the rainy season and winter alike. Similarly, there were no seasonal differences in nutritional management of village chickens, with 90.0% of village chicken flocks scavenging in all three seasons of the year. Additional feed such as rice (90.0%), food scraps (48.0%), maize/sorghum (25.0%) and broken rice (10.0%) were provided to chickens. Wells were the most common source of drinking water for all species (70.0-80.0%). No water was provided at home to approximately 5% of ruminant herds and 13% village chicken flocks (Table 4.3).

Table 4.3 Seasonal variation of feeding and watering practices conducted by cattle, small ruminant and village chicken farmers in the CDZ of Myanmar

No.	Feeding practice	Categories	Cattle		Small ruminants		Village chickens	
			N	Proportion with 95% CI	N	Proportion with 95% CI	N	Proportion with 95% CI
1.	Use of grazing areas	Summer	382	62.1* (54.2-69.4)	303	98.4 (95.2-99.5)	N/A	
		Rainy season	382	74.4 (66.8-80.8)	303	98.4 (95.2-99.5)		
		Winter	382	73.2 (66.0-79.3)	303	98.4 (95.2-99.5)		
2.	Provision of cut and carry local fodder grass	Summer	382	29.1* (22.9-36.1)	303	1.6 (0.5-5.4)	N/A	
		Rainy season	382	78.1 (71.8-83.3)	303	1.6 (0.5-5.4)		
		Winter	382	74.2 (67.8-79.7)	303	1.4 (0.3-5.4)		
3.	Provision of rice straw	Summer	382	47.2* (38.2-56.4)	303	1.9 (0.6-5.8)	N/A	
		Rainy season	382	13.9 (9.9-19.3)	303	1.9 (0.6-5.8)		
		Winter	382	12.4 (8.7-17.4)	303	1.9 (0.6-5.8)		
4.	Provision of crop residue**	Summer	382	71.3* (66.3-75.9)	303	11.7 (6.6-20.0)	N/A	
		Rainy season	382	41.6 (35.0-48.4)	303	10.8 (6.2-18.4)		
		Winter	382	43.5 (37.6-49.7)	303	10.5 (6.0-17.8)		
5.	Provision of groundnut cake ***	Summer	382	47.0* (38.2-56.0)	303	1.9 (0.7-5.4)	N/A	
		Rainy season	382	23.1 (17.9-29.3)	303	1.7 (0.5-5.3)		
		Winter	382	27.2 (21.3-33.9)	303	1.7 (0.5-5.3)		
6.	Provision of sesame cake***	Summer	382	54.9* (46.2-63.2)	303	1.4 (0.4-4.7)	N/A	
		Rainy season	382	27.7 (22.2-34.1)	303	1.1 (0.3-4.8)		
		Winter	382	28.0 (22.2-34.7)	303	1.1 (0.3-4.8)		
7.	Provision of maize or sorghum straw	Summer	382	67.4* (63.4-71.1)	303	2.3 (0.8-6.1)	N/A	
		Rainy season	382	55.5 (50.9-60.0)	303	2.3 (0.8-6.1)		
		Winter	382	58.3 (53.1-63.3)	303	2.0 (0.7-5.5)		
8.	Free range scavenging	Summer	N/A		N/A		327	88.7 (80.8-93.6)
		Rainy season					327	90.6 (82.9-95.1)
		Winter					327	90.2 (83.1-94.5)
9.	Provision of rice	Summer	N/A		N/A		327	88.7 (83.2-92.6)
		Rainy season					327	90.8 (86.4-93.9)
		Winter					327	92.3 (88.0-95.2)
10.	Provision of broken rice	Summer	N/A		N/A		327	10.7 (6.4-17.3)
		Rainy season					327	10.0 (5.8-16.5)
		Winter					327	9.7 (5.6-16.2)

No.	Feeding practice	Categories	Cattle		Small ruminants		Village chickens	
			N	Proportion with 95% CI	N	Proportion with 95% CI	N	Proportion with 95% CI
11.	Provision of peas	Summer	N/A		N/A		327	6.3 (3.0-12.6)
		Rainy season					327	6.1 (2.8-12.7)
		Winter					327	5.8 (2.6-12.4)
12.	Provision of household scrap	Summer	N/A		N/A		327	47.7 (38.8-56.8)
		Rainy season					327	45.7 (38.1-53.5)
		Winter					327	47.8 (39.5-56.2)
13.	Provision of maize	Summer	N/A		N/A		327	25.7 (19.1-33.7)
		Rainy season					327	22.9 (17.3-29.7)
		Winter					327	24.3 (17.9-32.0)
14.	Provision of water	Not provided	382	4.7 (2.7-8.0)	303	4.6 (2.3-8.9)	327	13.3 (8.2-20.8)
		River		0.9 (0.1-5.8)		2.8 (1.1-7.0)		1.0 (0.2-6.5)
		Well		78.6 (71.1-84.6)		68.1 (60.5-74.8)		69.7 (59.3-78.4)
		Lake		12.0 (7.4-18.9)		14.5 (9.7-21.1)		6.3 (3.5-11.0)
		Tap water		0.9 (0.3-2.9)		2.1 (0.7-6.6)		1.5 (0.4-5.9)
		Other		2.9 (1.7-5.2)		8.0 (4.9-12.8)		8.3 (4.7-14.1)

(Legend: Summer = March-May; Rainy season = June-October; Winter = November-February)

Chi-square with significance level of * = $p<0.05$ to identify seasonal effects; **By-products of first-stage processing of the harvested plants i.e., threshing and winnowing; *** By-products of second-stage processing of a plant part, usually what is left over from oil extraction.

Ruminants were generally provided with some form of shelter (cattle: 82.2%; small ruminants: 93.0%), while only 12.8% of farmers provided shelters for village chickens. A substantial proportion of cattle (82.2%) and small ruminant farmers (93.0%) provided overnight shelters for animals. A large proportion of cattle and small ruminants were provided shelter with natural material (Table 4.4). However, housing was more likely to be provided to cattle and small ruminants when they were kept alone, rather than in combination with other species ($p = 0.058$ for cattle; $p = 0.0218$ for small ruminants; Table 4.2).

Table 4.4 Characteristics of shelters provided to livestock species in the CDZ of Myanmar

Name of variables	Categories	Cattle		Small ruminants		Village chickens	
		N	Proportion with 95% CI	N	Proportion with 95% CI	N	Proportion with 95% CI
Provision of shelters	Yes	382	82.2 (77.5-86.1)	303	93.0 (89.2-95.5)	327	12.8 (9.4-17.2)
	No		17.8 (13.9-22.5)		7.0 (4.5-10.8)		87.2 (82.8-90.6)
Materials used for roof of shelters	No	314	0	276	0.3 (0.1-1.2)	327	N/A
	Corrugated metal		37.1 (27.9-47.4)		17.0 (11.0-25.4)		
	Thatch leaves		54.6 (44.3-64.6)		63.2 (52.2-72.7)		
	Plastic sheet		8.3 (4.3-15.2)		19.6 (11.5-31.3)		
Materials used for construct of fencing	No	314	86.2 (82.0-90.0)	276	19.2 (13.7-26.1)	327	N/A
	Bamboo		5.9 (3.5-10.0)		48.4 (37.9-59.1)		
	Wood		0.7 (0.2-3.6)		15.6 (8.7-26.6)		
	Plastic sheet		7.2 (4.7-10.8)		16.8 (11.7-23.6)		
Location where livestock is kept overnight	Separate building	382	77.5 (70.3-83.3)	303	86.8 (81.3-90.9)	327	1.7 (0.7-4.4)
	Tied to a tree		12.4 (8.8-17.3)		2.0 (0.6-6.9)		N/A
	Under the farm house		4.9 (2.8-8.5)		7.3 (4.4-11.9)		2.5 (1.1-5.5)
	Extension of the house		4.6 (2.2-9.3)		2.5 (1.0-6.2)		2.4 (1.0-5.9)
	Tethered in the grazing areas		0.6 (0.1-2.8)		1.1 (0.4-3.5)		N/A
	Resting in trees		N/A		N/A		68.2 (61.1-74.5)
	Sitting on the ground		0.0		0.3 (0.0-1.5)		15.5 (11.4-20.7)
	Sitting under a bamboo coop		N/A		N/A		9.7 (7.1-13.0)

Amongst ruminant-owning households, 56.8% (217 of 382) of cattle households and 89.8% (272 of 303) of small ruminant households used some form of breeding management. Cattle households commonly (86.7% or 188 of 217) used an adult male from outside the household for mating, but using their own male for breeding was the dominant approach for small ruminant owners (87.1% or 237 of 272). Of 217 cattle owners, 56.7% used an adult male from the same village for breeding, 27.7% used adult males from other villages, and 1.8% used both their own adult male and an adult male from other villages while 13.3% had no active mating management. In contrast, of the 272 small ruminant farmers, 11.8% used a male from the same village, and 1.1% used a male from other villages whereas the rest of the farmers (87.1%) largely relied on males from within their own herd. Only 0.5% of cattle farmers used artificial insemination (AI), while no AI was conducted in small ruminants.

Castration was more common in cattle households (64.9%, 227 out of 342) compared to small ruminant households (5.0%, 18 out of 297). Usually, older cattle were castrated, with 97.4% older than 12 months at the time of castration, and only 1.4% and 1.2% at 6-12 months and < 6 months, respectively. Out of the 18 small ruminant farmers practicing castration, 49.6% conducted castrations in animals older than 12 months, while 34.2% at 6-12 months and 16.2% at younger than six months.

4.5.5 Husbandry characteristics associated with purpose of cattle rearing

Univariate analysis results for the purposes of rearing are shown in Table 4.5. In the final multinominal multivariable model, there was only an association between the purpose(s) of keeping cattle rearing and cattle grazing. Grazing was more common for cattle kept for multiple purposes (OR: 7.3, 95%CI: 3.6-15.0) or exclusively for cash sales (OR: 6.9, 95%CI: 2.2-22.3) ($p<0.01$) compared to cattle kept for agriculture focus (i.e. draught purposes and production of manure for fertilizer). Predicted probabilities for practising grazing across the three purposes of cattle rearing are shown in Figure 4.4.

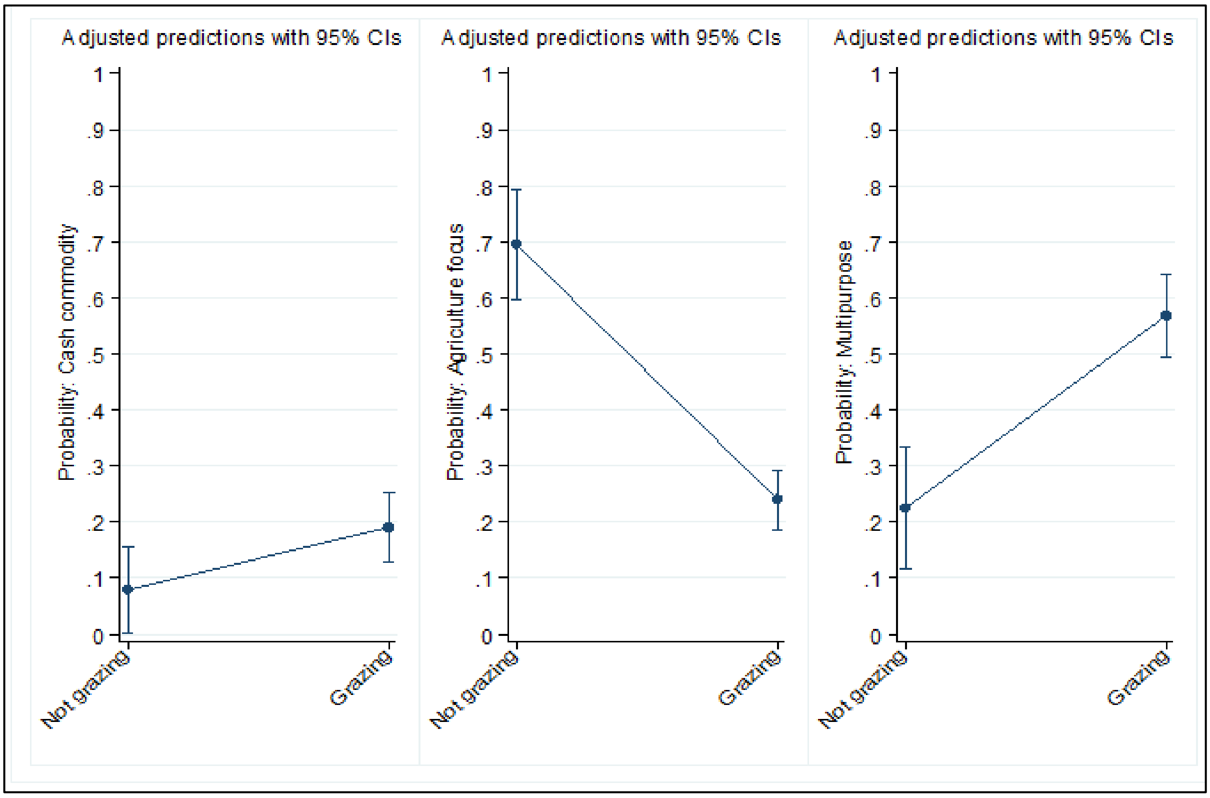


Figure 4.4 Predicted probabilities (95% confidence intervals) for purposes of rearing cattle and practising or not practising grazing

Table 4.5 Univariate analysis for factors associated with the purposes of raising cattle in the CDZ of Myanmar

Variables	Categories	N	Agriculture focus	Cash commodity			Multipurpose			
			%*	%*	RRR	p-value	%*	RRR	p-value	Wald test
Outcome variable: Purpose of rearing in cattle production										
Cash commodity - 52 (15.7%)										
Agriculture focus - 111 (33.5%)										
Multipurpose - 168 (50.8%)										
Main income source	Cropping	318	63.5	16.8	1		54.3	1		0.0037
	Livestock production		14.7	38.7	10.0 (3.2-31.1)	<0.0001	18.1	1.5 (0.6-3.3)	0.368	
	Labour		6.3	26.1	15.7 (3.7-66.8)	<0.0001	10.6	2.0 (0.8-4.7)	0.122	
	Shop owner		1.0	6.7	24.8 (4.8-129.6)	<0.0001	5.1	5.9 (1.1-32.5)	0.043	
	Supported by relatives		14.6	11.7	3.0 (1.0-9.7)	0.062	11.93	1.0 (0.4-2.3)	0.905	
Providing of housing	No	331	9.3	38.4	1		12.8	1		-
	Yes		90.7	61.6	0.2 (0.1-0.5)	0.002	87.2	0.7 (0.2-2.2)	0.530	
Materials used for roof of housing	Not provided	331	6.3	38.4	1		11.8	1		0.0046
	Corrugated metal		34.3	21.3	0.1 (0.0-0.3)	<0.0001	37.1	0.6 (0.2-1.9)	0.352	
	Thatch leaves		49.9	32.5	0.1 (0.0-0.4)	0.001	44.8	0.5 (0.2-1.5)	0.197	
	Plastic sheet		9.4	7.8	0.1 (0.0-0.8)	0.026	6.4	0.4 (0.1-1.7)	0.195	
Practise grazing	No	331	43.4	1.7	1		4.7	1		-
	Yes		56.6	15.1	6.9 (2.2-22.3)	0.002	44.9	7.3 (3.6-15.0)	<0.0001	
Provision of supplementary feed	No	331	7.0	49.1	1		10.4	1		-
	Yes		93.0	51.0	0.1 (0.02-0.3)	<0.0001	89.6	0.7 (0.3-1.5)	0.301	
Practise castration	Not practise	331	23.5	88.9	1		34.7	1		-
	Practise		76.5	11.1	0.0 (0.0-0.1)	<0.0001	65.3	0.6 (0.3-1.4)	0.206	
Cattle herd size	Low	331	57.7	56.9	1		22.1	1		<0.0001
	Medium		32.8	21.1	0.7 (0.3-1.4)	0.270	37.0	2.9 (1.7-5.1)	<0.0001	
	High		9.6	22.1	2.3 (0.6-9.4)	0.223	40.9	11.1 (3.7-33.5)	<0.0001	

4.5.6 Husbandry characteristics associated with herd or flock size

Larger cattle herds were more likely to practise grazing ($p<0.001$) and to employ labour from outside the household to manage cattle than medium or small herds ($p=0.03$; Table 4.6-4.7). In addition, larger cattle herds were more likely to be raised for multiple purposes (draught power, production of fertilizer, combined with sale of offspring) compared to the sale of offspring alone ($p< 0.05$). Amongst small ruminant households, larger herds/flocks were kept by farmers with longer experience of small ruminant ownership ($p=0.003$). Farmers keeping larger small ruminant herds were more likely to use their own males for breeding, rather than males from other flocks ($p<0.001$). For village chickens, only the provision of drinking water to birds was associated with larger flock sizes ($p=0.045$).

Table 4.6 Univariate analysis of factors associated with the herd/flock size of cattle, small ruminants and village chickens in the CDZ of Myanmar

Variables	Categories	N	Herd/Flock size (%)			Odds ratio	p-value	Wald test
			Low	Medium	High			
Outcome variable: Cattle herd size Low (1-3 heads) - 156 (40.9%) Medium (4-6 heads) - 130 (34.0%) High (>6 heads) - 96 (25.1%)								
Hire labour	No	382	91.0	83.7	76.0	1		-
	Yes		9.0	16.3	24.0	2.4 (1.3-4.4)	0.009	
Practise grazing	No	382	39.7	21.1	1.3	1		-
	Yes		60.3	78.9	98.7	5.5 (3.1-9.8)	<0.0001	
Outcome variable: Small ruminant herd size Low (1-20 heads) - 100 (33%) Medium (21-40 heads) - 127 (41.9%) High (>40 heads) - 76 (25.1%)								
Duration of practising goat production	<5 years	303	66.5	54.8	29.9	1		-
	>5 years		33.5	45.2	70.1	2.9 (1.5-5.4)	0.002	
Provision of housing	No	303	19.5	2.8	1.1	1		-
	Yes		80.5	97.2	98.9	11.2 (3.9-32.3)	<0.0001	
Materials used for fencing	None	303	53.7	14.1	10.9	1		<0.0001
	Bamboo		29.1	49.5	55.1	6.6 (3.1-14.3)	<0.0001	
	Wood		12.6	16.3	14.1	4.7 (2.0-11.1)	0.001	
	Plastic sheet		4.6	20.1	20.0	8.6 (3.8-19.4)	<0.0001	
Place of housing	Share the same shelter with farmers	303	17.6	8.7	3.6	1		0.0156
	Separate building		78.1	89.4	96.4	3.2 (1.5-7.1)	0.004	
	Tethering		4.3	1.9	0.0	0.7 (0.2-1.8)	0.403	
Way of breeding	Own male	272	70.8	93.8	99.2	1		-
	Other male		29.2	6.2	0.8	0.1 (0.0-0.3)	<0.0001	
Outcome variable: Village chicken flock size Low (1-7 heads) - 115 (35.2%) Medium (8-14 heads) - 98 (30%) High (>14 heads) - 114 (34.9%)								
Provision of water	Not provided	327	28.1	21.5	14.6	1		-
	Provided		71.9	78.5	85.4	1.8 (1.0-3.3)	0.045	

Table 4.7 Final models of factors associated with the herd/flock size of cattle, small ruminants and village chickens in the CDZ of Myanmar

Variables	Categories	N	Percentage (%)			Odds ratio	p-value	Wald test
			Low	Medium	High			
Outcome variable: Cattle herd size								
Low (1-3 heads) - 156 (40.9%)								
Medium (4-6 heads) - 130 (34.0%)								
High (>6 heads) - 96 (25.1%)								
Purpose of rearing	Cash commodity	382	56.9	57.7	22.1	1		0.0001
	Agriculture focus		21.1	32.8	37.0	1.2 (0.4-3.6)	0.685	
	Multipurpose		22.1	9.6	40.9	4.2 (1.8-9.9)	0.002	
Hire labour	No	382	91.0	83.7	76.0	1		-
	Yes		9.0	16.3	24.0	2.1 (1.1-4.0)	0.030	
Practise grazing	No	382	39.7	21.1	1.3	1		-
	Yes		60.3	78.9	98.7	4.3 (2.0-9.5)	0.000	
Outcome variable: Small ruminant herd size								
Low (1-20 heads) - 100 (33%)								
Medium (21-40 heads) - 127 (41.9%)								
High (>40 heads) - 76 (25.1%)								
Duration of practising goat production	<5 years	303	66.5	54.8	29.9	1		-
	>5 years		33.5	45.2	70.1	3.0 (1.5-6.2)	0.003	
Provision of housing	No	303	19.5	2.8	1.1	1		-
	Yes		80.5	97.2	98.9	5.2 (1.1-24.4)	0.037	
Materials used for fencing	None	303	53.7	14.1	10.9	1		0.0008
	Bamboo		29.1	49.5	55.1	4.0 (1.4-11.7)	0.011	
	Wood		12.6	16.3	14.1	2.1 (0.7-6.1)	0.192	
	Plastic sheet		4.6	20.1	20.0	5.0 (1.7-14.5)	0.004	
Way of breeding	Own male	303	70.8	93.8	99.2	1		-
	Other male		29.2	6.2	0.8	0.1 (0.1-0.3)	0.000	
Outcome variable: Village chicken flock size								
Low (1-7 heads) - 115 (35.2%)								
Medium (8-14 heads) - 98 (30%)								
High (>14 heads) - 114 (34.9%)								
Provision of water	Not provided	327	28.1	21.5	14.6	1		-
	Provided		71.9	78.5	85.4	1.8 (1.0-3.3)	0.045	

4.6 Discussion

This study describes current livestock production systems in Myanmar and, importantly, identifies how different livestock enterprises interact with each other within a household. Existing studies frequently focus on a single livestock species and do not evaluate associations between livestock enterprises, and thus may miss constraints or synergies faced by households owning multiple kinds of livestock (al-Naeem, Abu Elzein et al. 2000, Dreyer, Fourie et al. 1999, Henning, Pym et al. 2007).

As in many farming systems worldwide and particularly in the developing world, our study highlights that most of the small-scale farmers in the CDZ of Myanmar keep more than one species of animal (Amenu, Markemann et al. 2013, LIFT 2014, Maass, Katunga Musale et al. 2012). Our study also demonstrates that raising of village chickens in combination with cattle or small ruminants was more common than the combination of small and large ruminants, probably because chickens are managed easily, and do not compete for ruminant resources. Although we did not ask the reason for raising multiple species, nonetheless multispecies rearing may also have a number of benefits such as reducing economic risk associated with keeping single livestock enterprise and supporting other agricultural enterprises such as draught power for cultivating and land preparation (Devendra and Thomas 2002b). In addition, optimizing the use of husbandry resources by sharing animal housing, raising multiple livestock species such as raising village chickens with other livestock species is likely to spread the usage of scarce resources. However, raising multispecies is also challenging because farmers might not have finances and time to raise multiple species in their farm, in particular poorer or smaller households with limited resources.

Our finding suggested that farmers' awareness and knowledge of appropriate management practices for individual or multiple livestock species is limited. This represents a major constraint to improving productivity in livestock enterprises of CDZ. Interestingly, in general management practices did not differ among single species farms and multispecies farms. This might be due to farmers not having the resources and time to address the challenges and opportunities of raising multiple livestock species within the same household.

One interesting finding from our study is that there was no significant change in herd size for cattle and flock size for village chickens among farmers gaining more experience in raising these animals. In contrast, we noted a dramatic expansion in small ruminant herd sizes in farmers with more experience in small ruminants raising. One explanation might be that the majority of the farmers raised cattle for supporting other income sources (such as cropping) and chickens were largely raised for home consumption. Thus, expanding herd/flock sizes for direct income generation such as sales might not be a major concern for cattle and village chicken farmers. On the other hand, small ruminants were mainly raised for sales and experienced farmers are more aware of the increasing market demand for small ruminants.

Larger cattle herds were more likely to practise grazing. A number of studies have shown that additional time and labour is required to build larger livestock enterprises (IGS Budisatria, HMJ Udo et al. 2007, Kristjanson, Krishna et al. 2004, Morand-Fehr and Boyazoglu 1999) and our findings are consistent with these studies. The provision of freshly cut grass and potentially also supplementary feed is expensive for cattle farmers and therefore owners of larger cattle herds prefer the practice of grazing cattle. The use of additional labour might be a challenge for cattle farmers as labour migration and therefore decreased labour availability has been identified as a considerable constraint to livestock production in the CDZ (Kempel 2013, Phyo, Grünbühel et al. 2016). Where cattle were used for draught power for crop production, farmers were more likely to actively manage animal nutrition, such as providing supplementary or full feeding to cattle at home.

However, our findings also indicate that shelters were more likely to be provided to larger sheep and goat herds compared to smaller herds. This could be due to the fact that sheep and goats of larger numbers need to be managed more efficiently and also represent a more substantial monetary value. Small ruminants were usually only grazed, despite their additional nutritional requirements which should have resulted in the provision of supplementary feed by farmers.

Although dry and hot weather conditions are common in the CDZ, drinking water was mainly provided to larger village chicken flocks. Even though the reason is not clear, one possible explanation might be that in households with small flock sizes, village chickens might be mainly kept for home consumption and "pocket money" and therefore are not provided with the same level of adequate care as larger flocks. Provision of supplementary feed to village chickens is costly and is probably only justified when larger flocks are raised or village chickens are produced under semi-intensive farm conditions (Henning, Morton et al. 2008, J Henning, J Morton et al. 2013, Henning, Pym et al. 2007).

Our results showed that while on cattle farms outbreeding was common, most small ruminant farmers relied on males from within their own herd, indicating that inbreeding may has dominated small ruminant production. This is of concern as a number of studies reporting poor performance being associated with the practice of inbreeding (Fahmy and Shrestha 2000, Hermas, Young et al. 1987, Muasya, Githinji et al. 2006). However, without confirming exactly which rams/bucks are mated with which ewes/does it is difficult to assess the actual degree of inbreeding, in particular as outbreeding may have also been taking place by intentional or accidental mating by rams/bucks that stray between household flocks or during grazing. Overall, sheep and goat farmers seem to be unaware of benefits of outbreeding, or the impact of inbreeding on poor animal performance. On the other hand, inbreeding might not impact on small ruminant sale prices and therefore it is of less concern for farmers. Highlighting the benefits of outbreeding on cattle farms might be able to convince small ruminant farmers to change their breeding practices. Further research exploring the actual effect of in- and outbreeding would be highly recommended.

Although our study is the first to describe livestock husbandry practices in the CDZ of Myanmar, it also had a number of limitations. Firstly, data were collected on a memory recall by farmers which might affect the precision of the data collected. Secondly, herd and flock size information was collected for a single time point, which might not allow us to identify the seasonal variation of herd and flock sizes. And finally, our study mainly focused on the most common livestock species in CDZ, namely cattle, small ruminants and village chickens, but other livestock such as pigs and ducks are also raised in this areas (FAO 2011c).

4.7 Conclusions

Our study has shown that multispecies rearing by households is common and species-specific husbandry practices are implemented by farmers to reduce nutritional and health stresses. Although some practices are beneficial for one livestock species (e.g. supply of supplementary feed, provision of shelters and outbreeding), they are seldom applied to other species within the same household, despite the benefits these would likely bring. This highlights the need to evaluate the household's entire livestock production 'system' and shows that extension training should follow a 'holistic approach' including all livestock species raised in a household.

CHAPTER 5

IMPACT OF HUSBANDRY AND HEALTH MANAGEMENT PRACTICES ON SUMMARY MEASURES FOR MULTISPECIES LIVESTOCK REARING AND ON INCOME GENERATED FROM LIVESTOCK FARMING IN MYANMAR

5.1 Context

The chapter 4 identified types of livestock species reared within the same household, described management practices, herd or flock structures and highlighted the association between management practices and herd/flock sizes. As different livestock species are often kept together in the same household, understanding the major health problems and their management, and the factors influencing the income generated from livestock is important to develop sustainable interventions to improve livestock production and thereby the livelihood of livestock farmers in the Central Dry Zone (CDZ) of Myanmar.

In this chapter, we extend the analysis of husbandry factors from the previous chapter (Chapter 4) by focussing on syndromic animal health problems reported by farmers, animal health management practices implemented by farmers and the income generated from livestock production in the households. In particular, we describe the major health problems in each livestock species, develop a mark that summarizes animal health management, disease prevention and biosecurity practices that can be used in different livestock owning households and describe the associations between production and health parameters and the income from livestock production.

The findings from this research chapter help us to understand (i) the prevalence of syndromic animal health problems across different livestock species in the CDZ of Myanmar; (ii) the disease prevention and biosecurity practices implemented for different livestock species; and (iii) the major husbandry and management factors that influence animal health problems and income generated from livestock production.

5.2 Abstract

The Central Dry Zone (CDZ) of Myanmar is a critical region of livestock production. This region supports 10 million people whose livelihoods depend on small-scale, dry-land agriculture, but it is also one of the poorest regions of Myanmar. Little is known about the constraints to animal health in multi-species livestock farms in this region or the relationships between husbandry practices and measures of the success of livestock rearing such as income, and successful health management. In this study, we describe associations between husbandry practices and animal health problems affecting different body systems. We also develop a biosecurity and livestock disease prevention index that can be compared between livestock species, estimate the income generated from livestock production, and identify factors influencing these parameters. Surveys were used to collect data on livestock production and health from cattle, sheep, goat and village chicken farmers in 40 villages of the CDZ. Survey-design based techniques and F-statistics, ordinal, and binomial regression were used for data analysis. Our results indicate that a significant proportion of farmers' income in the CDZ comes from crop production (43.2%) and livestock production (23.1%) and the rest of the farmers' income is derived from trading, supported by other relatives and employment. Our results indicate that animal health management practices, herd/flock size, and experience of farmers contributed significantly to the presence of animal health problems, in particular related to the physical, respiratory and digestive systems. Animal health management was usually conducted in traditional ways. Among different livestock species farms, cattle farms (cattle median BDPI: 45; IQR: 35-55) practised better biosecurity than other livestock species farms (i.e. small ruminant and village chicken farms) (small ruminant and village chicken BDPI: 10; IQR: 0-20). Interestingly, the ownership groups (i.e. rearing singly or multispecies) did not show any impact on biosecurity and disease prevention index of the farms.

Keywords: multispecies, syndromic health problems, biosecurity, income

5.3 Introduction

Livestock production is one of the main income sources for rural households in developing countries and is often central to families' livelihoods (Devendra 1993, 2007, Steinfeld, Wassenaar et al. 2006). Therefore, understanding the factors influencing livestock production on small scale farms is essential if interventions to increase farmer income are considered (Kaimba, Njehia et al. 2011, Loibooki, Hofer et al. 2002). However, animals frequently serve multiple purposes within a household, such as the provision of meat, milk and manure fertiliser, in particular if more than one livestock species is kept on a farm (Devendra 1980, Thomas, Zerbini et al. 2002, Timon and Hanrahan 1986). Unfortunately most research studies have concentrated on a single livestock species, ignoring the interactions between a household's different livestock enterprises, and associations between multi-species rearing and factors such as health management or income generation (Nozières, Moulin et al. 2011). For example, livestock research in Myanmar focussed on separate agricultural enterprises without evaluating different livestock rearing activities within individual households or investigating a single disease and did not report the relative significance to other species within the same households (FAO 2011b, LIFT 2014). Thus, conducting research that focusses on the linkages, constraints and opportunities within a household's entire livestock rearing efforts will provide opportunities for more integrated, efficient and relevant strategies for improving livestock production.

In this study we describe health problems, health management practices and income generated by farmers owning single species or combinations of cattle, small ruminants and/or village chickens in the Central Dry Zone (CDZ) of Myanmar. We then develop a biosecurity and livestock disease prevention index that can be compared between livestock species, estimate the income generated from livestock productions and identify livestock management factors influencing both these parameters. Thus, our study focused on 'benefits' (i.e. income) and 'challenges' (i.e. management of health and biosecurity) from raising livestock by smallholders in the CDZ.

5.4 Material and Methods

5.4.1 Study design

A cross-sectional study using a questionnaire survey was conducted among small-scale farming households owning different livestock species in two administrative areas (townships), Myingyan and Meikhtila, in the CDZ of Myanmar. These two CDZ townships were identified as representative of typical livestock production systems in the CDZ by a research-for-development project investigating livestock production (ACIAR 2013).

The sampling approach was described previously (Chapter 3). In brief, a two-stage sampling approach was used with villages and households as the primary and secondary sampling units (PSU and SSU) respectively. Data were collected from a total of 40 villages within the two townships. Random sampling with replacement was used to select seven households each owning cattle, small ruminants and village chickens per village, providing a total of 21 households per village, to obtain at least seven households each owning cattle, small ruminants and village chickens. Sample size calculations and random sampling were performed using the Survey Toolbox modules Sample size for 2-stage prevalence survey (http://epitools.ausvet.com.au/content.php?page= SurveyToolbox) (Sergeant 2014a).

5.4.2 Questionnaire and data collection

A questionnaire was developed in English and was then translated into the local language (Myanmar). The questionnaire collected information about the livestock kept on each farm, current livestock husbandry practices, income generated from various sources, animal health problems, the management of animal health issues and biosecurity in the past 12 months (Chapter 4) and information on animal sales in the last two years . The survey was pilot-tested in two villages in Meikhtila township and the final version conducted by seven trained Myanmar enumerators from November 2014 to January 2015. The study was approved by the University of Queensland Human Research Ethics Committee (approval number #2014001425).

5.4.3 Development of animal health and production measures that can been compared between different livestock ownership groups

We developed three indicators, a) ‘livestock health problems’, b) ‘biosecurity and livestock disease prevention index (BDPI)’ and c) ‘income generated from livestock sale’, to compare the health and production practices and their impacts across different livestock ownership groups (Figure 5.1). As diseases are a major constraint to livestock production (Morgan and Prakash 2006, Perry, Kalpravidh et al. 1999, Perry and Rich 2007), we considered overall measures of syndromic health status by body systems as an indicator for general livestock health and subclinical disease. Appropriate treatments, targeted vaccinations and improved biosecurity might help to reduce the impact of livestock diseases (Conan, Goutard et al. 2012, Young, Evans-Kocinski et al. 2015), and we combined these interventions into a 'biosecurity and disease prevention' index as an indicator for preventive efforts made by farmers. Finally, as farm income generated is directly linked to the outputs of livestock production and the sales of animals (Alam 1997, Bailey, Hardin et al. 1997), we evaluated the income from livestock against other sources of household income (Adams and He 1995, Kristjanson, Krishna et al. 2004).

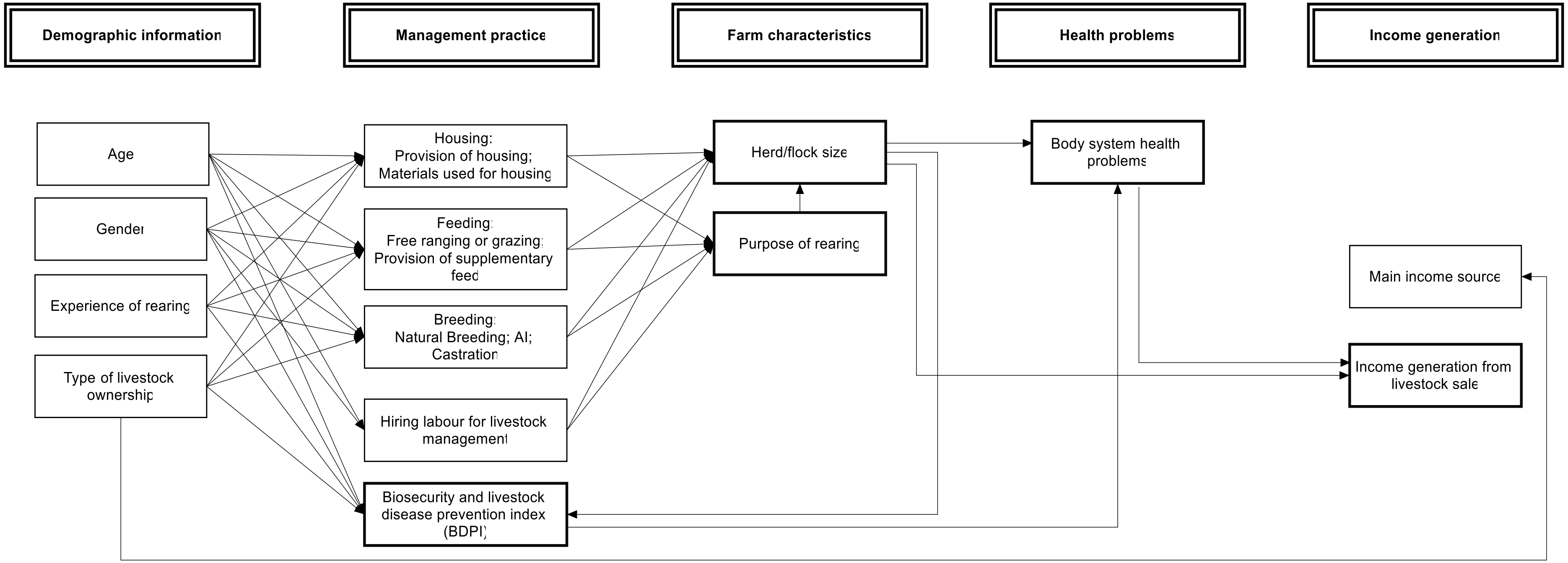


Figure 5.1 Hypothesized causal diagram of associations between husbandry factors, health indicators and income from livestock sales on cattle, small ruminant and village chicken farms in the CDZ of Myanmar

5.4.3.1 Livestock health problems

The occurrence of clinical signs in each livestock species over the 12 months preceding the interview was summarized in the following body system categories (regardless of the age and sex of infected animal): physical problems (e.g. sore or abnormal hoof, foot or leg causing abnormal movement in ruminants; and twisted head and neck in chickens), respiratory disorders (e.g. coughing, sneezing, discharge from the nose or other breathing problems), digestive disorders (e.g. constipation or straining to defecate, or pain in the belly, diarrhoea), nervous disorders (e.g. blindness, circling, abnormal behaviour), skin disorders (e.g. loss of hair/wool/feather, abnormal colour or appearance of skin, such as scabs on surface), reproductive disorders (e.g. abortions, offspring born dead, discharge from vulva in ruminants and poor egg quality; abnormal shape of egg; soft egg shell in chickens), urinary disorders (e.g. difficulty / straining to urinate, abnormal urine colour in ruminants), sudden death (Please see questionnaire for details) (Dórea, Sanchez et al. 2011, Shephard 2006).

5.4.3.2 Biosecurity and livestock disease prevention index (BDPI)

Information of preventive health activities conducted by farmers was combined into a 'biosecurity and livestock disease prevention index' (BDPI). Information provided by farmers on four separate activities (treatment of livestock, vaccination of livestock, activities to reduce disease transmission and sanitation) were summarized in separate marks and then combined into a final weighted index measure (Figure 5.2) (OIE 2017a).

The maximum number of marks was 20 and for data analysis, we converted the actual mark into a percentage rank (i.e. 20 marks representing a percentage rank of 100%). We used weighting of the individual marks in the calculation of the overall index measure to represent how easily and how frequently activities were carried out by farmers, and how effective they were for various disease controls. Biosecurity practices such as activities to reduce disease transmission and sanitation were weighted with 30% and 35% respectively, while treatment of livestock and vaccination of livestock had weights of 15% and 20%. Thus, biosecurity practices accounted for a large proportion of the overall index (i.e. total weight) (in particular for cattle farmers), while vaccinations had lower weightings (for example no vaccination was conducted by small ruminant farmers). This weighting also reflected that treatments or vaccinations alone would not provide excellent biosecurity on farms.

Marks for treatment of livestock reflected the likely probability of success and were determined to indicate the skills and knowledge of the person(s) providing both the advice on treatment and its actual administration, and the treatment's likely efficacy (i.e. a pharmaceutical product or a traditional remedy). The marks for vaccination of livestock reflected the likely probability of efficacy of the vaccination, based on whether or not it was conducted, the farmer's awareness of the target disease or type of vaccine used, and the skills and knowledge of the person administering the vaccine. Marks for reducing disease transmission represented the sum of activities that would improve biosecurity and potential spread of infection between animals, in particular whether contact between sick and healthy animals was minimized on the same farm, how long a sick animal was segregated, and whether farm entry by other people was limited. Finally, marks for sanitation represented the sum of activities that would be likely to reduce indirect transmission of pathogens between animals: removal of faeces, general cleaning procedures on the farm (e.g. sweeping, cleansing the area with water and removing rubbish from the farm or surroundings) and disinfection practices.

Activities that contributed to treatment and vaccination of livestock were combined multiplicatively, whereas marks for activities to reduce disease transmission and improve sanitation were combined additively. Thus, activities under treatment and vaccination represented independent events, with probability of them happening together being the product of their individual mark. For example, if treatment or vaccination of livestock was conducted, but by an inexperienced (lower marked) person, such as another farmer, the mark for this action was proportionately reduced, compared to an experienced (higher marked) person, such as a veterinarian. On the other hand, marks for activities to reduce disease transmission represented a set of independent outcomes that in their union represented a stronger mark. For example, implementation of quarantine of sick animals until recovery, minimizing contact with sick animals and reducing entry of people would result in the highest mark, but fewer activities would result in lower marks.

Factors that influence BDPI for each livestock species were then explored by percentile analysis. The BDPI was categorized into three groups: for all livestock species a BDPI of 0 indicated "No", while the 50^{th} percentile for BDPI was generated separately for each livestock species, with a BDPI below the 50^{th} percentile considered as low and above the 50^{th} percentile considered as high. Thus, the BDPI for the different livestock species was represented the following categories: no (0), low (1-45) and high (>45) in cattle farms; no (0), low (1-12.5) and high (>12.5) in small ruminant farms; and no (0), low (1-15) and high (>15) in village chicken farms.

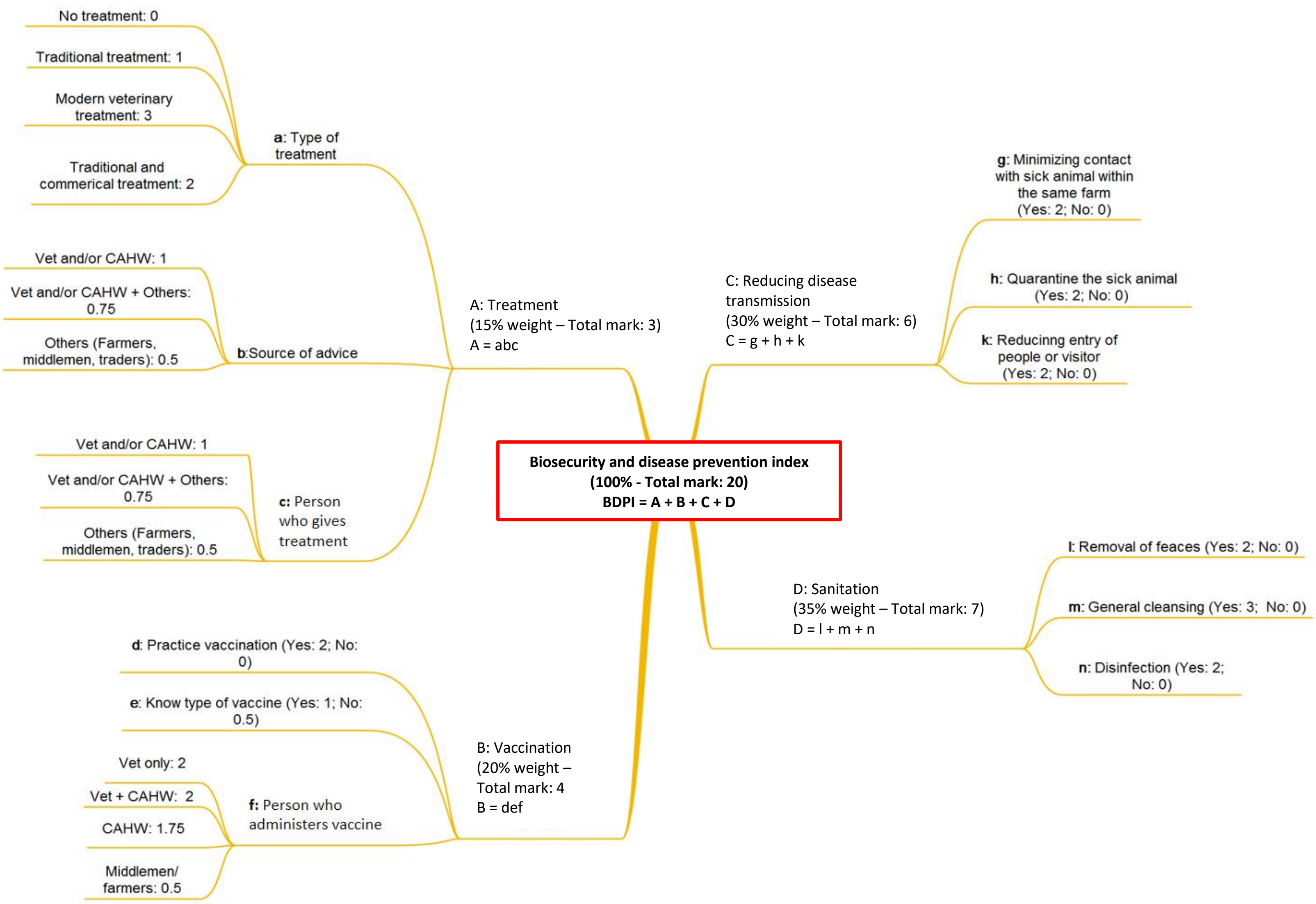


Figure 5.2 Flowchart for the calculation of the biosecurity and disease prevention index

5.4.3.3 Income generated from livestock sales

Total income from livestock sold was estimated for the two-year period before the interview. To understand the profit out of each livestock sale in CDZ, total income generated from each livestock species (cattle, small ruminants and village chickens) sold was calculated by multiplying the total number of animals sold within the two years with median market price over that period for each livestock species. If the farmers sold more than one livestock species, the calculation was done for each livestock species and the total income from livestock sales was derived by the sum of the income from all livestock sales. Median market prices of livestock species animals were obtained from seasonal sale prices specified by farmers over the last two years before the interview (considering the sex and if animals were juvenile or adult). There was some fluctuation in market prices of cattle and small ruminants across different seasons, but minimal seasonal variation for village chicken prices (Table 5.1). Therefore, we used the median value of market price regardless of the seasons and age groups assuming all animals sold were adult with median market price.

Table 5.1 Seasonal variation of sale prices reported by cattle, small ruminant and village chicken farms in the CDZ of Myanmar (Conversion rate US$ 1.0 = 1032.7 MMK) (http://usd.fxexchangerate.com/mmk-2014_12_31-exchange-rates-history.html)

Price	Summer (US$)			Rainy season (US$)			Winter (US$)		
	Offspring	Adult female	Adult male	Offspring	Adult female	Adult male	Offspring	Adult female	Adult male
Cattle									
Minimum	53.3	67.8	77.5	53.3	125.9	77.5	53.3	53.3	77.5
Median	290.5	338.9	503.5	290.5	387.3	677.8	290.5	377.7	542.3
Maximum	1,355.7	1,162.0	1,549.3	1452.5	2,711.3	3,776.5	1,355.7	871.5	1,500.9
IQR	193.7 -484.2	242.1 – 435.8	387.3 – 677.8	242.1 – 484.2	266.3 – 484.2	411.5 – 871.5	200.9 – 496.3	242.1 – 484.2	387.3 – 774.7
Small ruminants									
Minimum	14.5	14.5	38.7	29.1	14.5	19.4	29.1	19.4	33.9
Median	45.5	58.1	67.8	38.7	48.4	58.1	38.7	53.3	58.1
Maximum	67.8	484.2	968.3	58.1	774.7	968.3	58.1	774.7	968.3
IQR	29.1 – 58.1	48.4 – 77.5	48.4 – 96.8	29.1 – 42.6	43.6 – 72.6	48.4 – 96.8	30.3 – 50.6	38.7 – 77.5	43.6 – 96.8
Village chickens									
Minimum	N/A	1.9	1.9	N/A	1.9	1.9	N/A	1.9	1.9
Average (Median)	N/A	4.4	4.4	N/A	4.4	4.4	N/A	4.4	4.4
Maximum	N/A	43.6	43.6	N/A	43.6	11.6	N/A	8.7	11.6
IQR	N/A	3.9-4.8	3.9-4.8	N/A	3.9-4.8	3.9-4.8	N/A	3.9-4.8	3.9-4.8

To explore demographic and husbandry factors influencing income derived from livestock sales by comparing within the livestock enterprise, we calculated the median income for each livestock species and categorised income into three groups: no income (US$ 0 for all livestock ownership), less or equal to the median income, i.e. low (<US$ 450 for cattle ownership; <US$ 533 for small ruminant ownership; <US$ 373 for village chicken ownership), and larger than the median income, i.e. high (>US$ 450 for cattle ownership; >US$ 533 for small ruminant ownership; >US$ 373 for village chicken ownership).

5.4.3.4 Main income sources

To evaluate the importance of income from livestock sales in comparison to other income sources in the farming household, we established the scoring system using information provided by farmers during the interview as follows:

- Income generated from livestock sales per year
- Income from crop production per year
- Income from labour per year
- Income from trade per year
- Income received from relatives per year

We then identified the top income source for each household and then summarized the frequency of the top income sources for each livestock ownership group.

5.4.4 Statistical analysis

The data entry was conducted in a Microsoft Excel 2013 spreadsheet. Data were checked for data entry errors and validated by comparing digitized data with the original questionnaire by using NVivo Pro 11. Missing or suspicious data were discussed with interviewees over the phone. A causal diagram was created by using draw.io and NVivo Pro 11. Using Stata 14.0 (Stata Statistical Software, College Station, Stata Corporation, 2015), we used the survey-analysis approaches accounting for sampling weights, variance estimation (VCE), sampling strata (townships: primary sampling units PSUs) and clustering villages (secondary sampling units SSUs) (Cochran 1977, Deaton 1997, Nathan and Holt 1980, Wolter 2007).

Regression approaches were used for identifying associations between livestock management factors and livestock health problems and income from livestock sales considering hypothesized causal relationships (Figure 5.1). We used ordinal logistic regression for biosecurity and livestock disease prevention index (BDPI) and income from livestock sales, binomial logistic regression for presence-absence of livestock health problem for each body system. Thus, three regression models were developed for each livestock species (cattle, small ruminants, and village chickens). The proportional odds ratio assumption for ordinal regression models was tested by using the -omodel- command in STATA and the Brant test (Agresti 2013, Long 2003, Sloane and Morgan 1996). In addition, the variance of parallel regression analysis was tested by the significance test in the two tests (IRDE 2016). Predictors significant at $p<0.05$ in the univariable analyses were used firstly in the multivariable analysis, a forward selection and then backward elimination building procedure. The best fitted model was chosen by using Akaike Information Criterion (AIC).

5.5 Results

5.5.1 Livestock health problems

Physical problems (lameness, retarded growth, weakness, frequent recumbency in ruminants, twisted head and neck in village chickens) were reported in 23.3% of cattle, 35.6% of small ruminants and 32.5% of village chicken households. Respiratory disorders (coughing, sneezing, nasal discharge or other breathing problems) were reported in 40.0% of cattle, 53.3% of small ruminants and 7.9% of village chicken households, and digestive problems (drooling or sores in the mouth, unwillingness to eat or anorexia, constipation or straining to defecate, abdominal pain, diarrhoea) were common across all livestock species and were reported in 34.8% of cattle, 52.6% of small ruminants and 13.0% of village chicken households. Overall, small ruminant farmers reported the highest frequency of livestock health problems across all body system-related categories compared to cattle and village chicken farmers. In particular, reproductive problems were more commonly observed in small ruminants compared to the other livestock species (Figure 5.3).

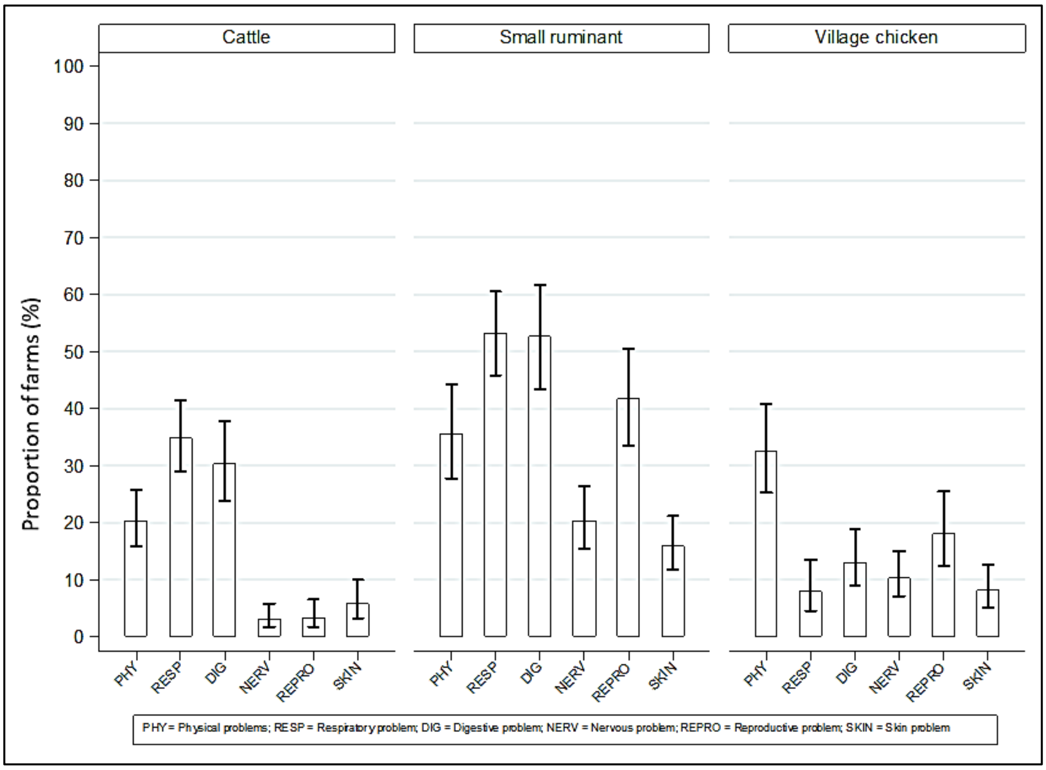


Figure 5.3 Proportion of cattle, small ruminant and village chicken farms reporting the presence of syndromic health problems within the last year before the interviews in the CDZ of Myanmar

Respiratory and digestive disorders in cattle were more common in adults than in offspring ($p<0.05$). Apart from digestive problems, which occurred most frequently in small ruminant offspring, all other health problems occurred more frequently in adult small ruminants ($p<0.05$). Problems of the digestive and the nervous system were more common in chicks than in older birds ($p<0.05$) (Table 5.2).

Table 5.2 Proportion of households reporting different animal health problems on cattle, small ruminant and village chicken farms in the CDZ of Myanmar

Body system affected	Age group	Cattle		Small ruminants		Village chickens	
		N	% (95% CI)	N	% (95%CI)	N	%(95%CI)
Physical disorders	Offspring	158	7.0 (3.9-12.2)	275	18.8 (12.1-27.9)*	218	25.5 (18.9-33.3)
	Adult female	243	15.2 (11.2-20.4)	291	33.1 (24.5-43.0)*	313	28.4 (21.1-36.9)
	Adult male	234	16.1 (11.3-22.3)	268	21.5 (15.6-28.7)*	209	26.3 (18.8-35.4)
Respiratory disorders	Offspring	158	12.0 (7.8-18.2)*	275	23.4 (19.0-28.4)*	218	5.6 (2.7-11.3)
	Adult female	243	26.3 (21.2-32.3)*	291	48.9 (41.5-56.4)*	275	3.4 (1.6-7.0)
	Adult male	234	30.2 (23.0-38.6)*	268	36.5 (29.1-44.5)*	185	6.4 (2.8-14.2)
Digestive disorders	Offspring	158	5.1 (2.5-9.9)*	275	45.7 (36.5-55.2)*	218	13.1 (8.6-19.6)*
	Adult female	243	23.9 (18.9-29.7)*	291	38.3 (32.0-44.9)*	275	9.4 (5.7-15.2)*
	Adult male	234	32.5 (24.4-41.8)*	268	25.9 (19.9-33.0)*	185	7.2 (4.0-12.5)*
Nervous disorders	Offspring	158	0.6 (0.01-4.4)	275	6.3 (3.4-11.2)*	218	10.2 (6.9-14.7)*
	Adult female	243	3.7 (1.9-7.0)	291	13.6 (9.6-19.0)*	275	2.2 (0.8-6.0)*
	Adult male	234	1.9 (0.6-5.9)	268	8.3 (5.5-12.3)*	185	3.0 (1.1-8.2)*
Skin	Offspring	158	3.8 (1.7-8.3)	275	7.7 (5.0-11.6)*	218	5.5 (2.5-11.5)
	Adult female	243	2.9 (1.4-5.9)	291	13.3 (9.5-18.4)*	275	4.3 (2.1-8.6)
	Adult male	234	5.3 (2.9-9.5)	268	9.5 (5.9-14.9)*	185	6.2 (2.9-12.5)
Reproductive disorders	Offspring	158	N/A	275	N/A	218	N/A
	Adult female	243	5.4 (3.1-9.0)	291	41.6 (33.3-50.4)*	275	16.2 (10.8-23.5)*
	Adult male	234	0.0	268	0.3 (0.1-2.6)*	185	3.8 (1.6-8.7)*

(= p<0.05, significant difference between age groups within species)*

Grazing practices, herd sizes, biosecurity and livestock disease prevention index were associated with health problems in different body systems (Table 5.3). The occurrence of respiratory and digestive disorders in cattle was associated with larger herd sizes ($p<0.001$), while physical disorders were more commonly observed on cattle farms that practise grazing ($p = 0.022$). The only health issue associated with different livestock species rearing combinations was digestive problems in village chickens, which occurred less frequently in birds in households that kept village chickens together with other livestock species, compared to households only keeping village chickens ($p= 0.025$). Surprisingly, more experienced small ruminant farmers practised poorer biosecurity and disease prevention than less experienced farmers. Also, observing digestive problems in small ruminants resulted in implementing better biosecurity and livestock disease prevention practices ($p <0.05$) (Table 5.3-5.4).

Table 5.3 Univariable analysis of factors associated with the reported occurrence of different livestock health problems on cattle, small ruminant and village chicken farms in the CDZ of Myanmar (each health problem-species combination represents a separate analysis)

Variables	Categories	N	Percentage (%)		OR	p-value	Wald test
			No	Yes			
Outcome variable: Physical disorders in cattle							
Yes – 74 (20.3%); No – 308 (79.7%)							
Herd size	Low	382	44.2	30.8	1		0.0294
	Medium		33.6	29.9	1.3 (0.6-3.0)	0.568	
	High		22.2	39.3	2.5 (1.1-5.7)	0.024	
Practise grazing	No	382	26.4	13.2	1		-
	Yes		73.6	86.8	2.4 (1.1-4.9)	0.022	
Outcome variable: Respiratory disorders in cattle							
Yes – 118 (34.9%); No – 264 (65.1%)							
Herd size	Low	382	53.1	19.8	1		<0.0001
	Medium		25.4	46.8	4.9 (2.8-8.7)	<0.0001	
	High		21.5	33.4	4.2 (2.4-7.2)	<0.0001	
Outcome variable: Digestive disorders in cattle							
Yes – 109 (30.4%); No – 273 (69.6%)							
Herd size	Low	382	48.3	25.7	1		0.0083
	Medium		31.1	36.8	2.2 (1.0-4.8)	0.042	
	High		20.5	37.5	3.4 (1.6-7.3)	0.002	
Outcome variable: Digestive disorders in small ruminants							
Yes – 146 (52.6%); No – 157 (47.4%)							
BDPI	Poor	303	34.7	19.9	1		0.0308
	Low		35.5	38.0	1.9 (1.1-3.2)	0.024	
	High		29.8	42.2	2.5 (1.2-5.0)	0.013	
Outcome variable: Digestive disorders in chickens							
Yes – 45 (13.0%); No – 282 (87.0%)							
Type of animal rearing in the same household	Chickens only	327	18.1	42.1	1		0.0250
	Cattle + Chickens		33.3	31.1	0.4 (0.2-1.0)	0.053	
	Small ruminants + Chickens		21.4	10.4	0.2 (0.1-0.6)	0.007	
	Cattle + Small ruminants + Chickens		27.2	16.4	0.3 (0.1-0.7)	0.008	
Outcome variable: Physical disorders in chickens							
Yes – 98 (32.5%); No – 229 (67.5%)							
BDPI	Poor	327	45.6	22.6	1		0.0047
	Low		32.0	34.6	2.2 (1.0-4.7)	0.046	
	High		22.4	42.7	3.8 (1.8-8.2)	0.001	

Table 5.4 Final model to identify factors associated with the reported occurrence of different livestock health problems on cattle, small ruminant and village chicken farms in the CDZ of Myanmar (each health problem-species combination represents a separate analysis)

Variables	Categories	N	Percentage (%)		Odds ratio	p-value	Wald test
			No	Yes			
Outcome variable: Physical disorders in cattle							
Yes – 74 (20.3%)							
No – 308 (79.7%)							
Practise grazing	No	382	26.4	13.2	1		-
	Yes		73.6	86.8	2.4 (1.1-4.9)	0.022	
Outcome variable: Respiratory disorders in cattle							
Yes – 118 (34.9%)							
No – 264 (65.1%)							
Herd size	Low	382	53.1	19.8	1		<0.0001
	Medium		25.4	46.8	4.9 (2.8-8.7)	<0.0001	
	High		21.5	33.4	4.2 (2.4-7.2)	<0.0001	
Outcome variable: Digestive disorders in cattle							
Yes – 109 (30.4%)							
No – 273 (69.6%)							
Herd size	Low	382	48.3	25.7	1		0.0083
	Medium		31.1	36.8	2.2 (1.0-4.8)	0.042	
	High		20.5	37.5	3.4 (1.6-7.3)	0.002	
Outcome variable: Digestive disorders in small ruminants							
Yes – 146 (52.6%)							
No – 157 (47.4%)							
BDPI	Poor	303	34.7	19.9	1		0.0308
	Low		35.5	38.0	1.9 (1.1-3.2)	0.024	
	High		29.8	42.2	2.5 (1.2-5.0)	0.013	
Outcome variable: Physical disorders in chickens							
Yes – 98 (32.5%)							
No – 229 (67.5%)							
BDPI	Poor	327	45.6	22.6	1		0.0047
	Low		32.0	34.6	2.2 (1.0-4.7)	0.046	
	High		22.4	42.7	3.8 (1.8-8.2)	0.001	
Outcome variable: Digestive disorders in chickens							
Yes – 45 (13.0%)							
No – 282 (87.0%)							
Type of animal rearing in the same household	Chicken only	327	18.1	42.1	1		0.0250
	Cattle + Chickens		33.3	31.1	0.4 (0.2-1.0)	0.053	
	Small ruminants + Chickens		21.4	10.4	0.2 (0.1-0.6)	0.007	
	Cattle + Small ruminants + Chickens		27.2	16.4	0.3 (0.1-0.7)	0.008	

5.5.2 Biosecurity and livestock disease prevention

More than half of village chicken owners did not treat sick chickens, while only 6.6% and 3.9% of cattle and small ruminant owners did not treat their sick animals. If treatment was conducted, the majority of the small ruminant (>60%) and village chicken owners (~50%) relied on traditional medicine, while the majority of cattle farmers (>60%) used veterinary health care providers alone or in combination with traditional medicine (Table 5.5) (Figure 5.4). Approximately 69.7% of village chicken and 63.3% of small ruminant owners did not implement any specific biosecurity measures to reduce the spread of livestock diseases, in contrast to 28.7% of cattle owners. The most common disease control approach was the segregation of sick animals (43.9%, 34.0% and 24.6% of cattle, small ruminant, and village chicken owners respectively), usually until recovery.

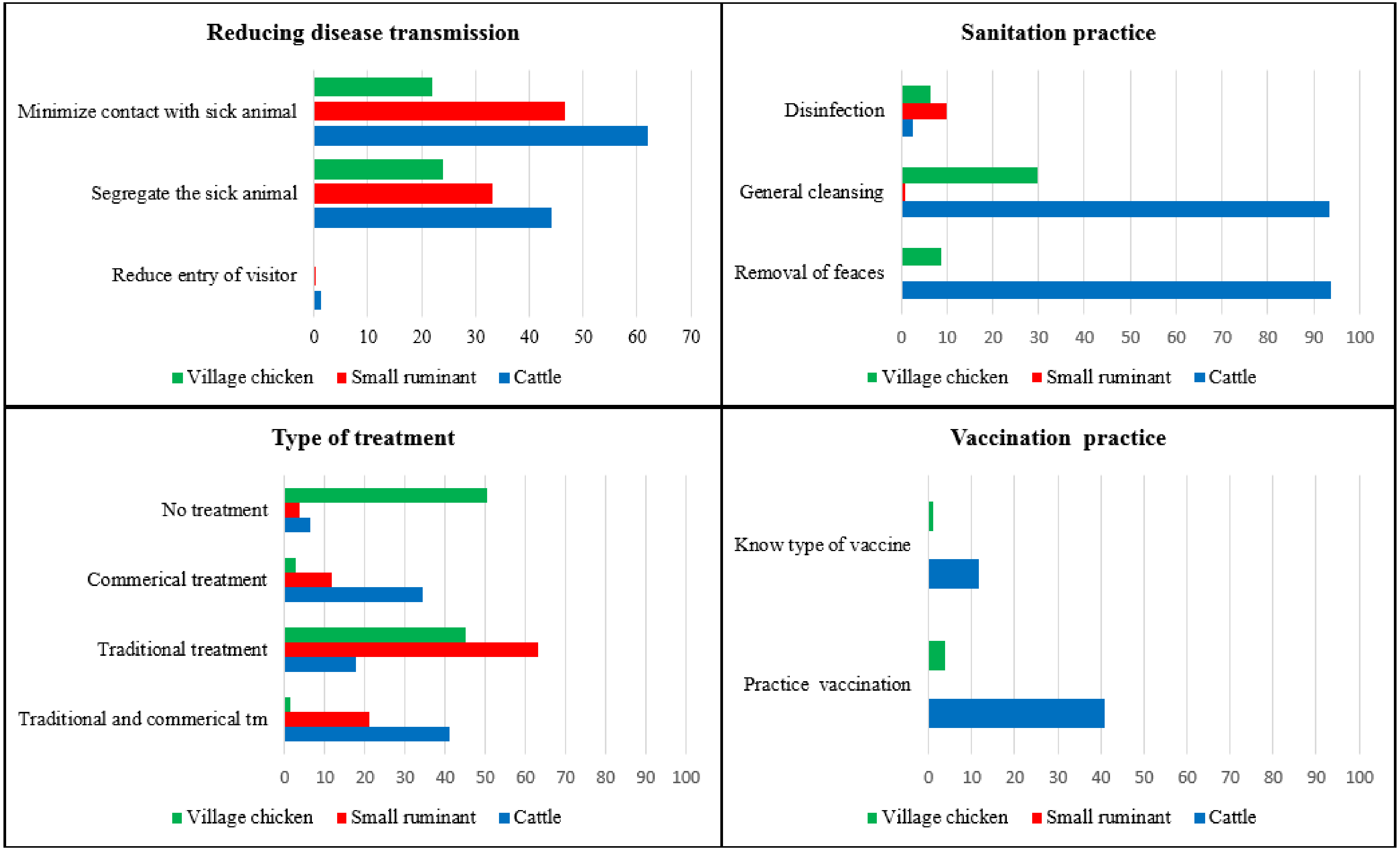


Figure 5.4 Proportion of cattle, small ruminant and village chicken farms in the CDZ of Myanmar conducting livestock treatment and vaccinations of livestock and implementing disease prevention and sanitation measures

Table 5.5 Health management and biosecurity practices conducted by cattle, small ruminant and village chicken farms in the CDZ of Myanmar

No.	Management practices	Categories	Cattle		Small ruminants		Village chickens		Comparison between different species	
			N	% (95% CI)	N	% (95% CI)	N	% (95% CI)	F-statistics	p
1.	Treatment of sick animals	Not conducted	382	6.6 (4.3-10.0)	303	3.9 (2.1-7.2)	327	53.4 (46.1-60.6)	72.5	<0.0001
		Traditional treatment*		17.7 (13.8-22.7)		63.4 (53.1-72.5)		43.1 (36.3-50.1)		
		Veterinary treatment		34.6 (27.8-42.0)		11.7 (8.2-16.5)		2.0 (0.9-4.6)		
		Both		41.1 (33.2-49.4)		21.0 (14.1-30.1)		1.5 (0.6-4.0)		
2.	Implementation of biosecurity measures on the farm	Yes	382	71.3 (64.7-77.1)	303	36.7 (29.6-44.3)	327	30.3 (24.1-37.4)	58.3	<0.0001
		No		28.7 (23.0-35.3)		63.3 (55.7-70.4)		69.7 (62.6-75.9)		
3.	Restrict entry of visitors to farms	Yes	382	1.2 (0.4-3.5)	303	0.4 (0.1-2.7)	327	0	199.3	<0.0001
		No		98.8 (96.5-99.6)		99.6 (97.3-99.9)		100		
4.	Disinfection conducted on the farm	Yes	382	2.7 (1.6-4.3)	303	9.0 (5.6-14.1)	327	3.6 (1.8-7.2)	7.5	0.0017
		No		97.3 (95.7-98.4)		91.0 (85.9-94.4)		96.4 (92.8-98.2)		
5.	Segregation of sick animals on the farms	Yes	382	43.9 (38.1-49.9)	303	34.0 (25.9-43.1)	327	24.6 (18.0-32.6)	6.3	0.0003
		No		48.6 (42.0-55.2)		60.6 (52.7-67.9)		66.4 (58.1-73.8)		
		Don't know		7.5 (4.9-11.4)		5.4 (3.4-8.6)		9.0 (6.4-12.5)		
6.	Segregation of sick animals until recovery	Yes	382	44.1 (38.3-50.0)	303	33.2 (25.1-42.4)	327	24.0 (17.8-31.4)	6.4	0.0004
		No		48.4 (41.9-55.0)		59.8 (52.0-67.2)		67.8 (59.6-75.0)		
		Don't know		7.5 (4.9-11.4)		7.0 (4.6-10.6)		8.2 (5.6-11.9)		

*(*E.g. local herbal drugs, indigenous way of treating)*

Cattle owners conducted better biosecurity and disease prevention practices (cattle median BDPI: 45; IQR: 35-55) compared to small-ruminant and village chicken farmers (small ruminant and village chicken BDPI: 10; IQR: 0-20) (Figure 5.5).

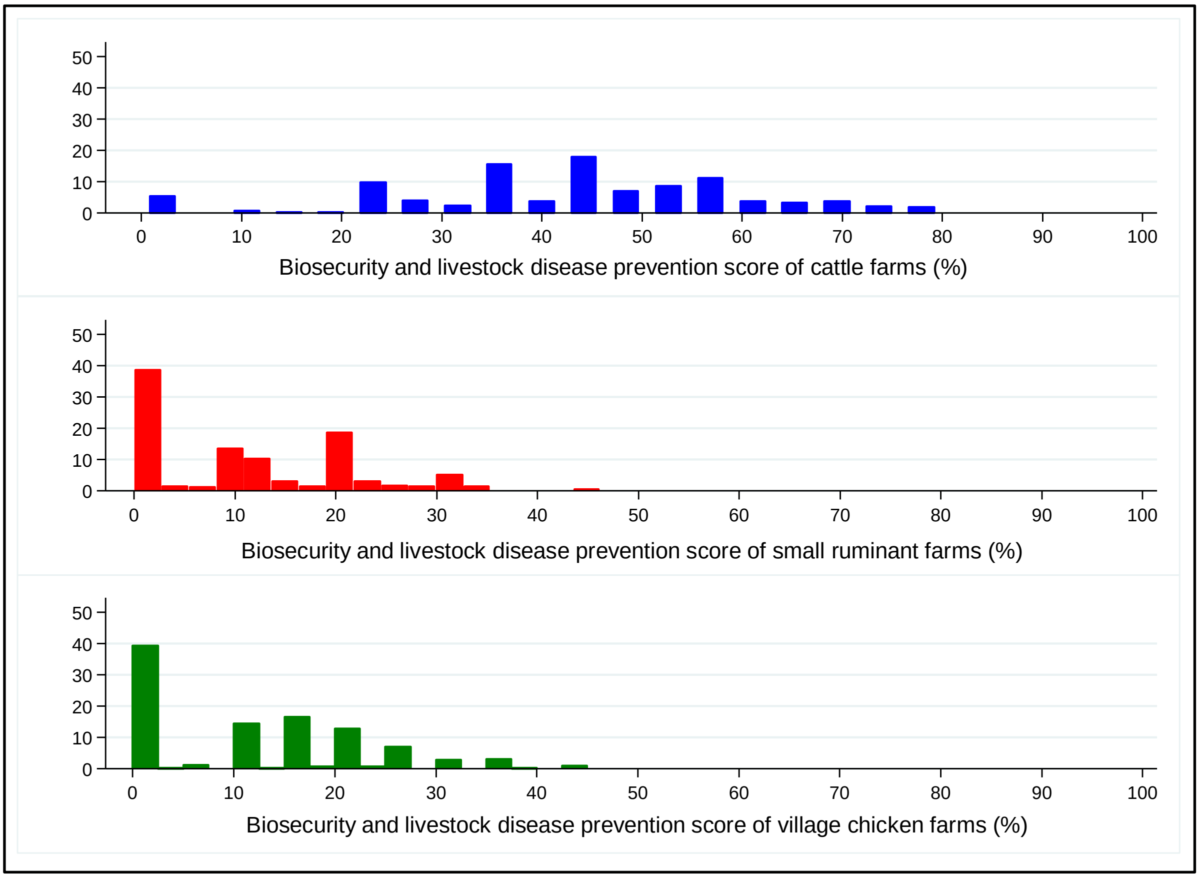


Figure 5.5 Proportion of cattle, small ruminant and village chicken farms with different biosecurity and livestock disease prevention indices in the CDZ of Myanmar

The biosecurity and livestock disease prevention index (BDPI) was similar within each of the three livestock ownership groups, when cattle, small ruminants or village chickens were kept in combination with other livestock species (Figure 5.6).

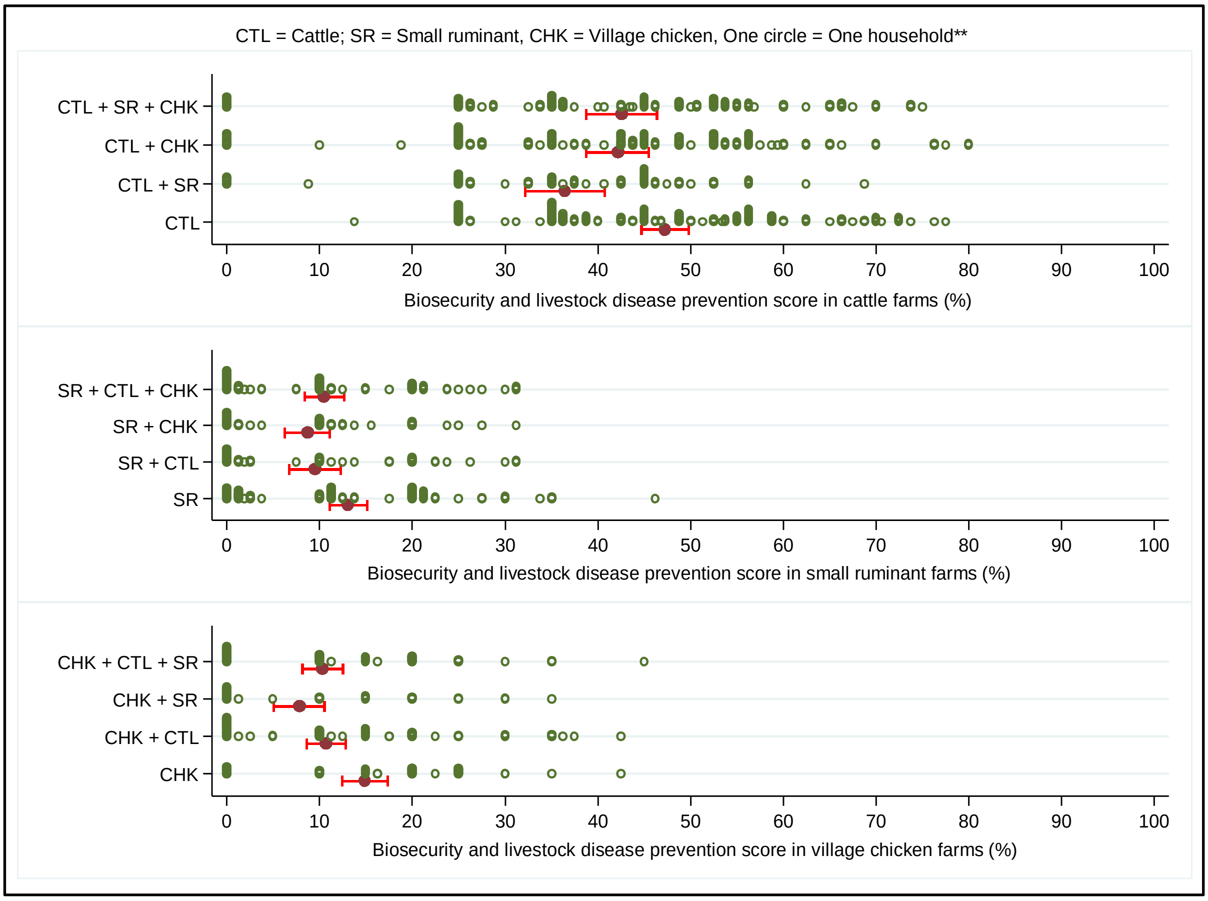


Figure 5.6 Distribution of biosecurity and livestock disease prevention indices on farms raising combinations of cattle, small ruminants and village chickens in the CDZ of Myanmar

Better biosecurity and livestock disease prevention practices were implemented by cattle and village chicken farmers with more than five years of experience in raising these livestock species, with farms with a longer history of keeping animals having 1.9 (village chickens) and 3.0 (cattle) times the odds of having a greater BDPI score than those with a shorter history of ownership (Table 5.6-5.7).

Table 5.6 Univariable analysis to identify factors affecting biosecurity and disease prevention indexes (BDPI) on cattle, small ruminant and village chicken farms in the CDZ of Myanmar

Variables	Categories	N	BDPI (%)			Odds ratio	p-value	Wald test
			No	Low	High			
Outcome variable: BDPI in cattle farms No (0%) – 20 (5.0%) Low (1-45%) – 197 (51.1%) High (>45%) – 165 (43.9%)								
Duration of rearing cattle	<5 years	382	22.1	11.9	4.7	1		-
	>5 years		77.9	88.1	95.3	3.0 (1.0-9.0)	0.049	
Outcome variable: BDPI in small ruminant farms No (0%) – 79 (26.9%) Low (1-12.5%) – 117 (36.8%) High (>12.5%) – 107 (36.3%)								
Duration of rearing sheep	<5 years	303	77.9	86.5	94.7	1		-
	>5 years		22.1	13.5	5.3	0.3 (0.2-0.6)	<0.0001	
Outcome variable: BDPI in village chicken farms No (0%) – 126 (38.1%) Low (1-15%) – 106 (32.9%) High (>15%) – 95 (29.0%)								
Type of animal reared	Village chickens only	327	14.8	18.5	32.7	1		0.0026
	Cattle + Village chickens		25.4	42.2	32.7	0.6 (0.2-1.8)	0.391	
	Small ruminants + Village chickens		34.1	11.6	10.8	0.2 (0.1-0.5)	0.001	
	All 3 spp.		25.7	27.8	23.7	0.5 (0.2-1.4)	0.179	
Duration of rearing village chickens	<5 years	327	31.2	22.4	16.0	1		-
	>5 years		68.8	77.6	84.0	1.9 (1.2-2.9)	0.004	

Table 5.7 Final model to identify factors affecting biosecurity and disease prevention indexes (BDPI) on cattle, small ruminant and village chicken farms in the CDZ of Myanmar

Variables	Categories	N	% of households in BDPI category			Odds ratio	p-value	Wald test
			Poor	Low	High			
Outcome variable: BDPI in cattle farms								
Poor (0%) – 20 (5.0%)								
Low (1-45%) – 197 (51.1%)								
High (>45%) – 165 (43.9%)								
Duration of rearing cattle	<5 years	382	22.1	11.9	4.7	1		-
	>5 years		77.9	88.1	95.3	3.0 (1.0-9.0)	0.049	
Outcome variable: BDPI in small ruminant farms								
Poor (0%) – 79 (26.9%)								
Low (1-12.5%) – 117 (36.8%)								
High (>12.5%) – 107 (36.3%)								
Duration of rearing sheep	<5 years	303	77.9	86.5	94.7	1		-
	>5 years		22.1	13.5	5.3	0.3 (0.2-0.6)	<0.0001	
Outcome variable: BDPI in village chicken farms								
Poor (0%) – 126 (38.1%)								
Low (1-15%) – 106 (32.9%)								
High (>15%) – 95 (29.0%)								
Type of animal reared	Village chickens only	327	14.8	18.5	32.7	1		0.0020
	Cattle + Village chickens		25.4	42.2	32.7	0.6 (0.2-1.7)	0.336	
	Small ruminants + Village chickens		34.1	11.6	10.8	0.2 (0.1-0.5)	0.001	
	All 3 spp.		25.7	27.8	23.7	0.5 (0.2-1.3)	0.134	
Duration of rearing village chickens	<5 years	327	31.2	22.4	16.0	1		-
	>5 years		68.8	77.6	84.0	1.9 (1.3-3.0)	0.002	

5.5.3 Income generated from livestock sales

Of the 613 farmers surveyed, 435 farmers (69.1%) reported that they sold animals in the two years before the interview, while 178 farmers (30.9%) did not sell animals. Amongst the latter, households that did not sell animals represented 36.9% of cattle, 18.9% of small ruminant and 23.2% of village chicken owners.

Excluding the households with no history of sale, the patterns of sales were similar for cattle and village chickens owning households that sold livestock across different livestock ownership groups, with a median of 1-2 cattle and 8-9 village chickens being sold in the past two years before the interviews (Figure 5.7). However, the median number of small ruminants sold varied across different livestock ownership groups with sales: 10 sheep or goats on small ruminants only farms, 8 on farms with cattle and small ruminants, 14 on farms with small ruminants and village chickens, and 7 on farms with cattle, small ruminants and village chickens.

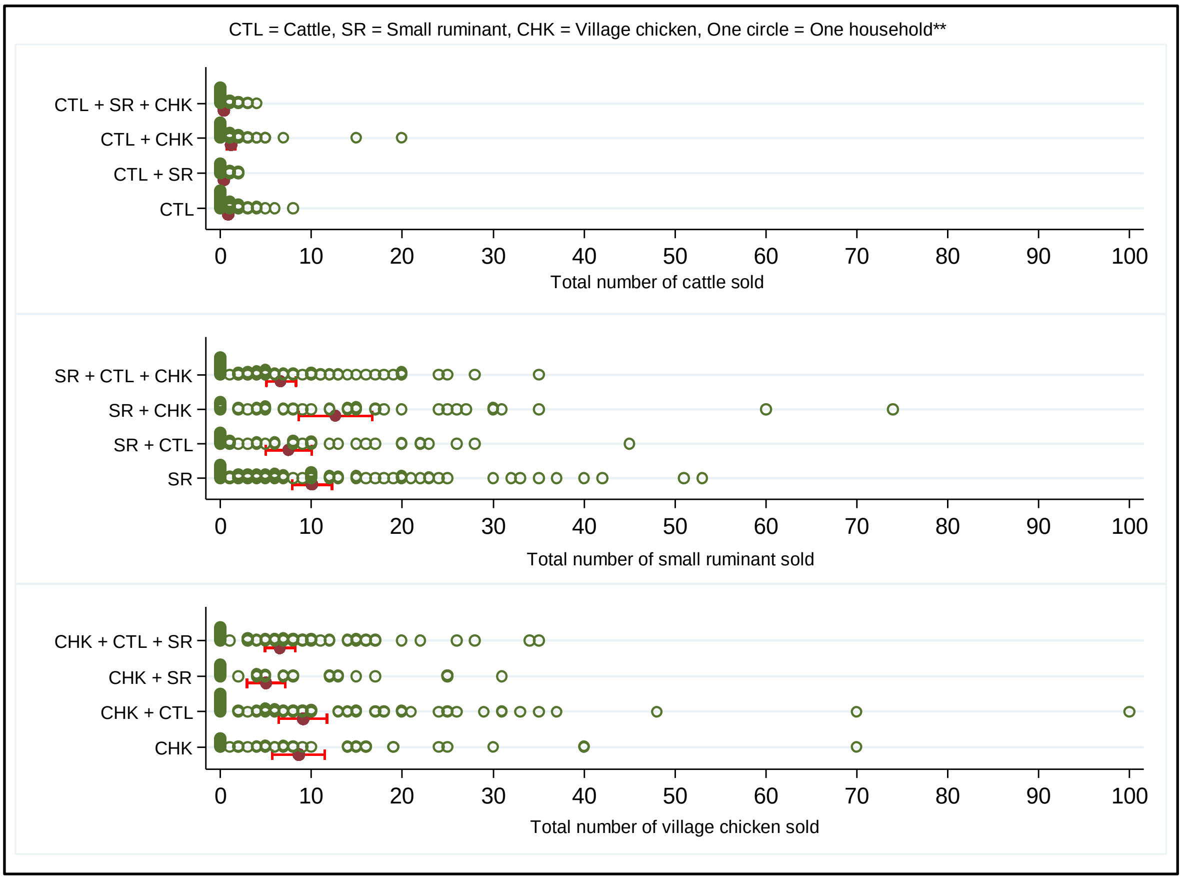


Figure 5.7 Number of animals sold in two years before the interview on farms raising combinations of cattle, small ruminants and village chickens in the CDZ of Myanmar (red horizontal bar indicates the mean of the number of animal sales with 95% confidence interval)

The distribution of income from farms with livestock sales is shown in Figure 5.8. Households with only village chickens generated the lowest income. The median income (IQR) generated in village chicken, small ruminant and cattle only farms over the two year period from sales of livestock was 34.9 USD (21.8-69.7), 532.6 USD (266.3-905.4) and 755.3 USD (377.7-910.2) respectively. Households keeping village chickens or small ruminants with other livestock species were more likely to earn higher income from livestock sales, whereas cattle households raising small ruminants and/or chickens reported lower income from livestock sales (Table 5.8).

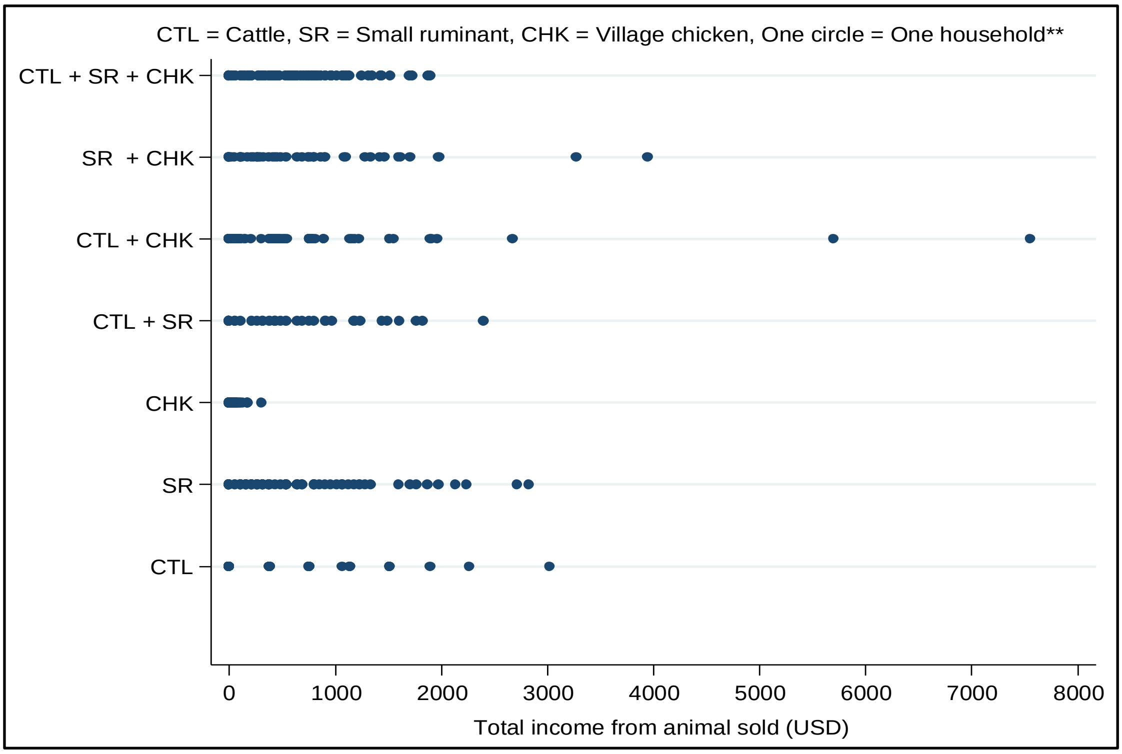


Figure 5.8 Total income generated from livestock sales within the last two years before the interviews on farms raising different combinations of livestock species in the CDZ of Myanmar

Higher income from livestock sales occurred for cattle and village chicken farmers when additional livestock species were kept within the same household. In small ruminant-owning households, greater livestock income occurred in herds/flocks that experienced respiratory or digestive problems (Table 5.9-5.10).

Table 5.8 Total income generated from livestock sale within the past two years before the interview on farms raising combinations of cattle, small ruminants and village chicken in the CDZ of Myanmar (http://usd.fxexchangerate.com/mmk-2014_12_31-exchange-rates-history.html)

Average income from livestock sale (US$)	Cattle	Small ruminants	Village chickens	Cattle + Small ruminants	Cattle + Village chicken	Small ruminants + Village chickens	Cattle + Small ruminants +Village chickens
Minimum	377.7	53.3	4.4	53.3	8.7	8.7	13.1
Median	755.3	532.6	34.9	585.8	386.4	639.1	556.6
Maximum	3021.2	2822.7	69.7	2396.6	7553.0	3941.1	1894.6
IQR	377.7-910.2	266.3-905.4	21.8-69.7	334.1-1171.7	56.7-755.3	266.3-1093.7	279.4-907.6

Table 5.9 Univariable analysis to understand factors affecting income generated from livestock sale cattle, small ruminant and village chicken farms in the CDZ of Myanmar **This cut-off represent the median income from the sale of animals of this livestock species*

Variables	Categories	N	Income (%)			OR	p-value	Wald test
			Low	Medium	High			
Outcome variable: Income generated from livestock sale in cattle farmers								
No income (US$ 0) – 128 (36.9%)								
Low (< US$ 450) – 127 (32.2%)*								
High (> US$ 450) – 127 (30.9%)								
Type of animal reared	Cattle only	382	56.0	19.5	22.6	1		<0.0001
	Cattle + Small ruminants		13.2	9.7	22.5	4.1 (1.4-11.5)	0.009	
	Cattle + Village chickens		20.6	40.8	25.9	3.0 (1.6-5.4)	0.001	
	Cattle + Small ruminants + Village chickens		10.2	30.0	29.1	4.7 (2.4-9.3)	<0.0001	
Reproductive problem	No	382	99.3	96.3	93.9	1		-
	Yes		0.7	3.7	6.1	3.4 (1.3-8.9)	0.012	
Outcome variable: Income generated from livestock sale in small ruminant farms								
No income (US$ 0) – 55 (18.9%)								
Low (< US$ 533) – 131 (39.9%)*								
High (> US$ 533) – 117 (41.1%)								
Digestive problem	No	303	63.4	49.7	37.8	1		-
	Yes		36.6	50.3	62.2	2.0 (1.3-3.2)	0.003	
Reproductive problem	No	303	75.9	63.8	45.0	1		-
	Yes		24.1	36.2	55.0	2.6 (1.4-4.6)	0.002	
Outcome variable: Income generated from livestock sale in village chicken farms								
No income (US$ 0) – 72 (23.2%)								
Low (< US$ 373) – 129 (39.7%)*								
High (> US$ 373) – 126 (37.1%)								
Types of animal reared	Village chickens only	327	32.4	34.5	0	1		<0.0001
	Cattle + Village chickens		37.8	27.6	35.9	3.2 (1.8-5.5)	<0.0001	
	Small ruminants + Village chickens		11.1	14.5	31.2	7.5 (3.6-15.3)	<0.0001	
	All 3 spp.		18.7	23.4	32.8	4.8 (2.3-10.3)	<0.0001	

Table 5.10 Final model to identify the factors associated with the income from livestock sales on cattle, small ruminant and village chicken farms in the CDZ of Myanmar ****This cut-off represent the median income from the sale of animals of this livestock species***

Variables	Categories	N	% of households in income category			Odds ratio	p-value	Wald test
			Low	Medium	High			
Outcome variable: Income generated from selling cattle								
No income (US$ 0) – 128 (36.9%)								
Low (< US$ 450) – 127 (32.2%)*								
High (> US$ 450) – 127 (30.9%)								
Type of animal reared	Cattle only	382	56.0	19.5	22.6	1		0.0003
	Cattle + Small ruminants		13.2	9.7	22.5	4.1 (1.4-12..0)	0.013	
	Cattle + Village chickens		20.6	40.8	25.9	3.1 (1.7-5.9)	0.001	
	Cattle + Small ruminants + Village chickens		10.2	30.0	29.1	5.1 (2.5-10.3)	<0.0001	
Reproductive disorders	No	382	99.3	96.3	93.9	1		-
	Yes		0.7	3.7	6.1	4.5 (2.2-9.3)	<0.0001	
Outcome variable: Income generated from selling small ruminants								
No income (US$ 0) – 55 (18.9%)								
Low (< US$ 533) – 131 (39.9%)*								
High (> US$ 533) – 117 (41.1%)								
Digestive disorders	No	303	63.4	49.7	37.8	1		-
	Yes		36.6	50.3	62.2	0.6 (0.1-1.0)	0.023	
Reproductive disorders	No	303	75.9	63.8	45.0	1		-
	Yes		24.1	36.2	55.0	0.8 (0.3-1.3)	0.001	
Outcome variable: Income generated from selling village chicken								
No income (US$ 0) – 72 (23.2%)								
Low (< US$ 373) – 129 (39.7%)*								
High (> US$ 373) – 126 (37.1%)								
Types of animal reared	Village chicken only	327	32.4	34.5	0	1		<0.0001
	Cattle + Village chickens		37.8	27.6	35.9	3.2 (1.8-5.5)	<0.0001	
	Small ruminants + Village chickens		11.1	14.5	31.2	7.5 (3.6-15.3)	<0.0001	
	All 3 spp.		18.7	23.4	32.8	4.8 (2.3-10.3)	<0.0001	

5.5.4 Main income sources

A total of 590 respondents provided information on all their household income sources: 43.2% of farmers obtained their highest income from cropping; 23.1% from livestock production; 15.6% from employment; 11.7% from support by relatives ('remittances') and 6.4% from trade (Figure 5.9).

The top income sources for different livestock ownership are shown in Figure 5.9. For all cattle owning households (keeping cattle only or in combination with other livestock species) cropping was the main income source. For all small ruminant farmers (keeping small ruminants only or in combination with other species), livestock production (and sales) was the dominant income source. When village chickens were raised alone or with cattle, cropping was the main income source, but when village chickens were kept with small ruminants, livestock sales were the top income source.

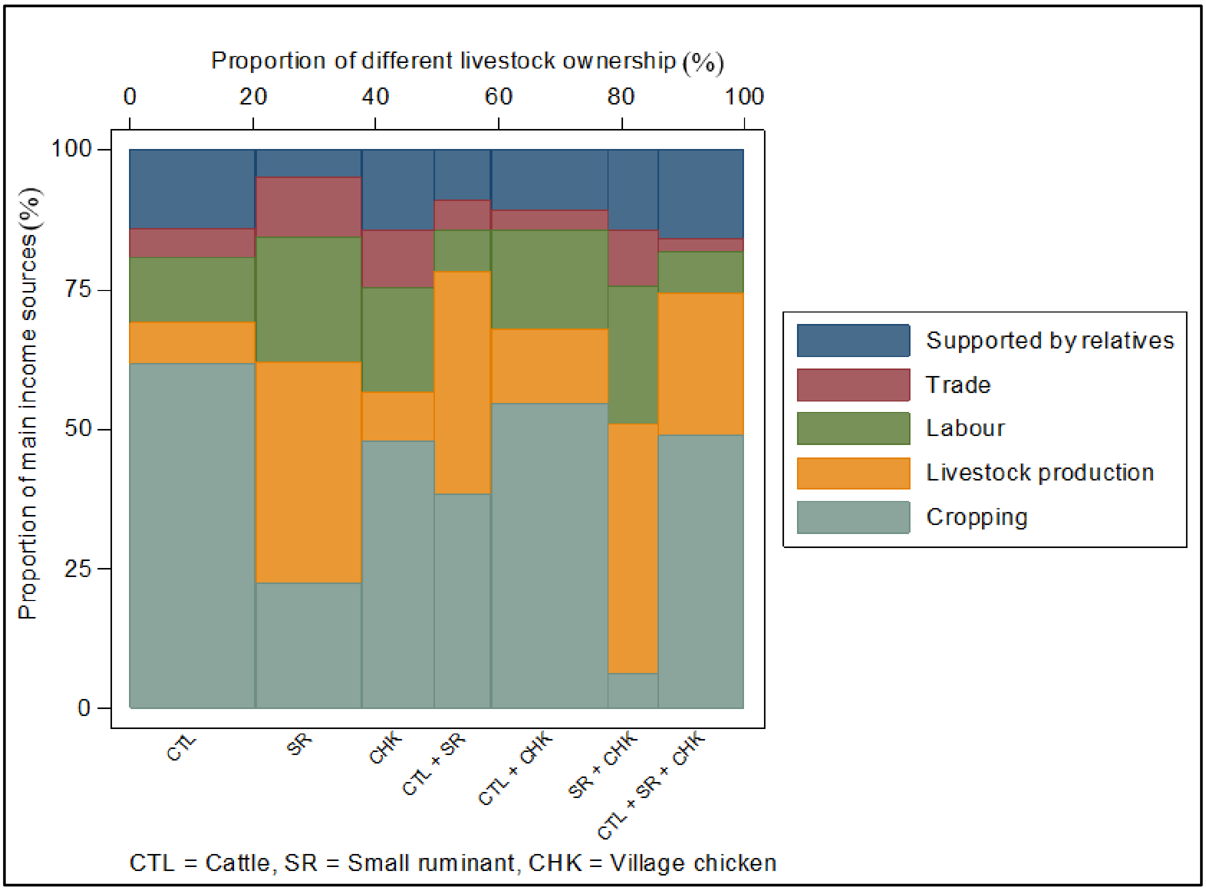


Figure 5.9 Proportion of main income sources for farms raising different combinations of livestock species in the CDZ of Myanmar (width of columns indicates the proportion of farms owning each combination of livestock species)

5.6 Discussion

In this research we identified key constraints to livestock production and health, and thereby farmer livelihoods from small-scale cattle, goat/sheep and village chicken production in the CDZ of Myanmar. We adopted a syndromic approach to summarize health problems in order to avoid the use of intensive resources and multiple panels of diagnostic tests and to reduce potential information bias associated with a survey team's clinical expertise in diagnosing livestock diseases. This approach has been used before in Myanmar for village chicken health problems (J. Henning, J. M. Morton et al. 2013), but not to date on small ruminant or cattle farms.

'Physical' health problems were most commonly observed in village chickens. This syndromic category included signs such as twisted head and neck, which are consistent with Newcastle disease, a common and important disease of poultry in the CDZ (Adwar and Lukesova 2008, Henning, Morton et al. 2008, Henning, Morton et al. 2010). A similar phenomenon was observed in small ruminant-owning households that reported digestive problems in their animals. This suggests that farmers do respond to disease events, even those owning species that principally rely on 'traditional' remedies and have poorer access to formal health services. This awareness suggests that additional government support for disease prevention would likely be welcomed by farmers and have a beneficial effect on further disease control.

In cattle and small ruminants, 'respiratory' and 'digestive' signs were most common, followed by 'reproductive' signs in small ruminants. Similar observations were made in two villages of the CDZ, where syndromic health of small ruminants was monitored monthly over a period of 12 months (July 2015 to June 2016) (Hanks, Glanville et al. 2018) . The reported prevalence of health problems in cattle was lower than in the two other livestock species under study. This might be explained by the fact that cattle are normally the livestock species with the highest market value and for that reason cattle farmers might be more willing to spend money in the treatment for aimed at improving biosecurity and disease prevention for these species.

Our study showed the pattern of clinical syndromes varied between different-sized cattle holdings, with digestive and respiratory problems reported more frequently in larger herds compared to smaller ones. It is possible that increasing herd/flock size challenges farmers' management skills, limiting the success or sustainability of keeping greater livestock numbers (Muma, Samui et al. 2006, Oo 2010, Yongolo, Machangu et al. 2002). Additionally, increased trading as a household's livestock holdings grow may present new disease threats. Feeding practices were also associated with cattle health in that poor nutrition as a result of animals mainly fed via grazing might increase their disease susceptibility, or this feeding strategy may increase contact with animals outside the household and facilitate disease spread. This information identifies classes of livestock that may warrant more attention from farmers and health services. It suggests extension and support for livestock health and production may benefit from being tailored to different enterprise sizes (Chawatama, Mutisi et al. 2005, Henning, Pym et al. 2007, Mazumder, Kalita et al. 2014, Thomas, Zerbini et al. 2002), and not assume that a 'one size fits all' approach to livestock health for each species is appropriate.

Our previous study highlighted that livestock in CDZ of Myanmar is raised in traditional ways, such as by provision of grazing (Zaw Win, Campbell et al. 2017). The present study extends these findings to the widespread use of traditional medicines to treat health problems. Furthermore, the decision to use 'commercial veterinary products' for treating animal diseases is likely to be driven by the value of the animals, explaining why in our study cattle were more often treated with commercial products compared to other species (Ahuja 2013, Oo 2010). Our findings of a greater reliance on farmer-sourced, traditional remedies strongly supports anecdotal observations that there is poorer communication between health providers, including government, and goat/sheep and village chicken owners than those keeping cattle. This likely has flow-on effects into poor awareness of cross-species disease transmission risks and biosecurity practices; among different livestock ownership groups, our study noted that biosecurity and disease prevention practices were more common on cattle farms than small ruminant or village chicken farms. Further studies to investigate the factors affecting farmers' decisions in relation to animal health care are required to inform strategies to improve animal health care provision in the CDZ of Myanmar.

Despite biosecurity and infection control being relevant to the management of all the livestock species covered in our study (Conan, Goutard et al. 2012, Fraser, Williams et al. 2010, Gunn, Heffernan et al. 2008), there was considerable variation between livestock enterprises in how well these were practised. In turn, this likely impacts the profitability and sustainability of these different enterprises. Health problems and biosecurity practices were not associated with different livestock ownership combinations on small ruminant and cattle farms. However, on village chicken farms, poor biosecurity practices were more common amongst multispecies-rearing households, as the BDPI was lower when chickens were kept with other livestock species. This suggests farmers preoccupied with other activities were less likely to give attention to village chicken health management, as the chicken is a low capital source of income (Henning, Khin et al. 2006). This is important in terms of lost opportunities for those households and also identifies a group of households more at risk of potentially important diseases, such as avian influenza. Despite these findings, fewer digestive disorders were actually reported in village chickens in multispecies-rearing households compared to households raising only village chickens. However, it has to be considered that signs of clinical disease in village chickens might have been underreported as they are of lower importance compared to other livestock species in multispecies households.

One of the unexpected findings from our study is that farms with health disorders in cattle and small ruminants were more likely to earn greater income. One explanation could be that the farmers tend to sell unwell animals rather than treat them. This may be a result of poor farmer understanding of disease management or they might not be aware of the benefit of the good health care practice on farms. This especially occurred in small ruminant herds. We recommend further research to describe the associations between an animal's health status and sale price, and farmer attitudes and knowledge of livestock trading, animal health status and risk of disease spread.

It was interesting to note that about one fifth of small ruminants and one quarter of village chicken households sold no animals in the two years preceding our study, despite these species typically being kept to generate cash income. A better understanding is required of the factors that influence livestock sales and hence household income, as increased farmer awareness of market volatility and the most suitable time or age of animals to sell, or improved trading resources and connections with value chains may improve household income.

There were a number of obstacles and potential limitations in our study typical of research in this area. We adopted a syndromic approach to describe occurrence of health problems to overcome the frequent lack of accurate disease diagnosis in the CDZ. To compare management of different livestock species, we developed a summary measure of biosecurity and livestock disease prevention index (BDPI). Even though we tested adjustment and validation of the scores to get reliable data, the index would nonetheless benefit from further validation and evaluation in different management scenarios. Lastly, few farmers kept animal health, production or trading records. Therefore, it was necessary to calculate average market values from the data collected from farmers because it was very hard to get reliable data from individual farmers. Because livestock prices are relatively volatile (FAO 2011b), future longitudinal studies are required to better collect more reliable livestock price and household income data.

Our study has shown that different livestock enterprises, and combinations thereof, vary in their role in household livelihoods and in terms of constraints they face in the Central Dry Zone of Myanmar. Despite the significance of these enterprises to household incomes, health problems are common. Nonetheless, all livestock systems contained examples of good biosecurity and disease management practices. Households using these methods would serve as leaders in extension programs to improve production and health management. This is likely to be especially important for systems containing comparable species combinations and of similar size, as adopting a 'one size fits all' approach to improving production and health would be less likely to address the important nuances in livestock production our study has described. This study identified good practice households and these findings will be useful for designing intervention trials to improve the production and health outcomes evaluated in this study.

CHAPTER 6

FACTORS INFLUENCING SMALL-SCALE FARMERS' DECISIONS TO VACCINATE THEIR ANIMALS AGAINST COMMON INFECTIOUS LIVESTOCK DISEASES

6.1 Context

The previous chapters (Chapter 4 and 5) focussed on describing livestock production and livestock health in the CDZ and on identifying management factors that inhibit improving production and health. We also noted a high prevalence of reported symptoms that could be associated with clinical cases of FMD in cattle and small ruminants and ND in village chickens. Based on confirmed and unconfirmed reports, incidence of FMD and ND is high in the CDZ with a high morbidity of clinical signs and high mortality rates in case of FMD. However, FMD and ND can be prevented with vaccinations, but we need to understand the factors and perceptions and beliefs of farmers that influence their decisions to have their animals vaccinated against FMD and ND.

In this chapter, we use the health belief model to describe the farmers' perception of the severity of FMD and ND, the barriers to practising vaccination, the availability of information about vaccinations, and perceived effectiveness of vaccination. We then identify the factors influencing farmers' attitudes and awareness towards FMD and ND vaccination practices. This information will help to develop appropriate FMD and ND control strategies considering the perceptions of farmers.

6.2 Abstract

Livestock rearing is an important income source for small-scale farmers in Myanmar, but FMD and ND disease are major constraints to livestock production. A study was conducted to identify perceptions of farmers about FMD and ND disease risks and perceptions about vaccination practices. A total of 613 small-scale farmers owning cattle, small ruminants and/or village chickens were interviewed using a Health Belief Model framework. We evaluated the perceptions of farmers owning different livestock species and developed a path model to describe the causal relationships influencing the decisions of farmers to vaccinate or not to vaccinate their livestock. The majority of livestock farmers (>70%) reported that they were aware of the risk of FMD and ND and the impact of these diseases, but the response differed between livestock ownership groups ($p<0.001$). A total 88% of cattle farmers, 84% of small-ruminant farmers and 71% of village chicken farmers were willing to vaccinate their animals ($p<0.001$). About 17.0% of cattle, 15.4% of village chickens, but only 2.3% of small ruminant owners indicated that the non-availability of vaccinations in the villages was a major constraint to vaccinations ($p<0.001$), while in contrast twice as many small ruminant farmers compared to cattle and village chicken farmers indicated they had no knowledge about vaccinations and no funds to conduct vaccinations. About 19.4% of cattle, 38.3% of small ruminants, but 57.7% of village chicken owners indicated that no information is provided to them about the prevention of major infectious diseases ($p<0.001$). Local authorities were the main provider of information on disease prevention and vaccinations (although less frequently on ND prevention in village chickens), while traders were an important additional source of information about FMD vaccinations for small ruminant farmers. Using path analysis, we identified that the perceptions on the effectiveness of vaccination, poor knowledge about the use of vaccination and limited availability of vaccine and vaccinators limited the willingness of farmers to conduct vaccinations, while the perceived impact of the diseases increased farmers willingness for preventive actions. On the other hand, indirect factors, such as village size strongly influenced the availability of vaccinations. Our study highlights that policies that increase the accessibility of vaccines and the dissemination of information about disease prevention and vaccination practices in village of all sizes, have the potential to increase FMD and ND vaccination rates and thereby reduce outbreak occurrence in Myanmar.

Keywords: Foot and Mouth Disease, Newcastle disease, vaccination, perception, farmers, livestock

6.3 Introduction

Multispecies small-scale livestock production is the main form of livestock rearing in many developing countries (Thien 2000). In Myanmar, cattle are usually raised for land preparation, while small ruminants are sold for meat and village chickens provide supplementary income. Livestock diseases can have devastating impacts on livestock rearing by these small-scale farmers and threaten food security, economic and social development in these developing countries. Among them, Foot and Mouth Disease (FMD) and Newcastle Disease (ND) commonly cause reduced performance and slow growth or deaths in animals (OIE 2017a). FMD results in reduced efficiency of cattle used for draught power and reduced reproductive performance (Bellet, Vergne et al. 2012, Mahy 2004, Nampanya, Suon et al. 2012, Oo 2010, Perry, Gleeson et al. 2002). On a national level, FMD occurrence will result in trade restrictions (Cai 2012, Cocks, Robertson et al. 2012, Edwards 2003, Oo 2010, Ozawa 1993). Newcastle disease (ND) is associated with high mortality rates in village chickens and often results in the complete loss of village chicken flocks (Biswas, Barua et al. 2009, Dutta, Islam et al. 2013, Henning, Morton et al. 2008, Liang, Cao et al. 2002).

Vaccination is an important method for preventing and controlling infectious diseases (Gallili and Ben-Nathan 1998, Mahy 2004). In developing countries, vaccination is usually conducted by veterinarians or para-veterinarians employed through the national government veterinary services (Lubroth, Rweyemamu et al. 2007). Ultimately, livestock farmers usually decide if their livestock should be vaccinated. Major factors that might influence farmers' decisions whether or not to vaccinate include farmers' previous experience with the disease occurrence, social pressure, awareness of the benefits of vaccination, accessibility to information about vaccination, resources to conduct vaccination, and personal motivations, but demographics such as gender, age, and socioeconomic status also play a part (Bennett and Balcombe 2012, Mainar-Jaime and Vázquez-Boland 1999, Sok, Hogeveen et al. 2016, Wassink, Moore et al. 2005, Zhang, Young et al. 2017). Understanding attitudes and beliefs about vaccinations as well as barriers for vaccination are important to develop efficient and sustainable disease control strategies. However, it is unknown what influences vaccination practices of small-holder farmers in developing countries, in particular on multispecies rearing farms.

Various approaches can be used to study attitudes, perceptions and behaviours (Liu, Ho et al. 2018, Yam, Lam et al. 2017, Zhang, While et al. 2012). One of the them is the Health

Belief Model (HBM) framework, which was introduced into health educational research in the 1950s by social psychologists Hochbaum, Rosenstock, and Kegels (Becker 1974, Maiman and Becker 1974). Since then, the HBM framework has been widely used by health psychology researchers to explore the relationship between human cognitive behaviour and health preventive measures, in particular the psychological influences on taking preventive actions to improve human health (D'Souza, Zyngier et al. 2011, Dodel and Mesch 2017, Montanaro and Bryan 2014). However, the HBM framework has not been widely used to research preventive veterinary actions. We used the HBM framework to investigate the relationship between the perceptions of livestock farmers on barriers and benefits of FMD and ND vaccination and their willingness to practise vaccination against FMD in cattle and small ruminants and ND in village chickens.

6.4 Material and Methods

6.4.1 Study design, sample size and selection of sampling units

This cross-sectional study was conducted with small-scale farmers in two administrative areas in the Central Dry Zone of Myanmar, the Myingyan and Meikhtila Townships. Subjects for the HBM questionnaire were drawn from a larger sample of households that were surveyed about their cattle, small ruminant and chicken ownership and production (Chapter 4). For this wider survey, a two-stage sampling approach was used with villages being the primary sampling units (PSUs) and farms the secondary sampling units (SSUs). Sample size was based on the expected proportion of farm income that was generated from livestock production. The proportion of farm income that was generated from livestock production was expected to be 0.7, with a moderate variation of farm income from livestock production within villages of 0.1 (due to similar ecological conditions), a between cluster variance (between villages variance) of 0.025. Precision of the estimate was set to 0.05 with 95% confidence interval. The number of villages per township was 400 and total farms per village was approximately 200. The online calculator Epi Tools was used to estimate the required sample size using the probability proportion to size algorithm (Sergeant 2014c). A total of 40 villages and 20 farms per village needed to be surveyed and were selected from a sampling frame of villages provided by the Livestock Breeding and Veterinary Department (LBVD) Myanmar. In selected villages seven households in each livestock ownership group (cattle, small ruminants, village chickens) needed to be interviewed, thus a total of 21 farms per village were selected using simple random sampling from a list of village households. A total of 280 farmers of each livestock ownership groups (cattle, small ruminants and village chickens) were subsequently targeted for follow-up interviews on their attitudes towards and practice of FMD and ND vaccination, as detailed below.

6.4.2 Questionnaire and data collection

The HBM questionnaire (including 13 questions relating to each livestock species) was firstly developed in English and then translated into Myanmar (Burmese) language. The questionnaire captured data on demographics, disease prevention practices, individual farmer's perception on FMD and ND, the effectiveness of and barriers to vaccination and various factors that could impact the likelihood of farmers to have their livestock vaccinated. The questionnaire was tested in two villages representing affluent and poor villages selected by expert opinion based on village infrastructure, size of the village and opportunities for trade in the villages. Experts included seven members of local authorities, three animal health workers and two research officers. After the pilot testing, some items were modified in the questionnaire. The survey was conducted by seven trained interviewers comprising of two veterinary medicine students from the University of Veterinary Science, Yezin, four staff from LBVD and the lead author of this paper. Total interviewing time was approximately 20 minutes for each interview.

HBM framework

We used a modified HBM framework to summarize the perceptions of farmers on their willingness to implement vaccinations against FMD and ND. Some questions on HBM components were open-ended (i.e. perceived benefits and cues to action) and were categorized or converted into multiple dichotomized (yes/no) variables for further analysis. We assumed that the farmers (4.6% of cattle farmers; 2.8% of small ruminant farmers; 3.0% of village chicken farmers) who reported 'don't know' to some HBM components were likely to be unaware of the particular item and included these 'don't know' answers in the 'no' category. The following modified HBM components were utilized in this study:

1) ***Knowledge about disease:*** Ability of farmers to recognize clinical signs for FMD in ruminants and for ND in village chickens (yes/no). Triangulation to identify farmers' ability to recognize FMD and ND was done by asking clinical signs, and host.

2) ***Perceived severity (impact of the disease):*** Perception of farmers that occurrence of FMD and ND can result in economic losses (i.e. reduced sales or reduced sale prices or unwillingness of traders to purchase disease animals) (yes/no).

3) ***Perceived benefits (effectiveness of the vaccination):*** Perception of farmers that FMD and ND vaccination can prevent the occurrence of FMD and ND (yes/no).

4) ***Perceived barriers (barriers to vaccination):*** Perceived barriers to conduct FMD and ND vaccinations were categorised into three groups: farmers' knowledge about the use of vaccination to control FMD and ND (yes/no), availability of vaccination in the village (yes/no) and farmer's access to funds to pay for vaccination (yes/no).

5) ***Cue to action (availability of information about vaccination):*** Accessibility of information on FMD and ND vaccination and vaccination programmes was categorised into four groups: availability of information about vaccination (yes/no), provision of information about vaccination through veterinary administrative officers, local veterinarians and veterinary animal health workers (yes/no); provision of information about vaccination through other farmers (yes/no); and provision of information about vaccination through traders (yes/no).

The willingness of farmers to have their animals vaccinated against FMD or ND was used as the outcome variable (yes/no).

We also collected data on factors that could have impacted on HBM components, such as village size, demographic information of farmers (median age: ≤47 years old and >47 years old; gender: male and female; duration of livestock rearing: ≤5 years and >5years), type of animal species reared: raising single species only (cattle/ small ruminants/ village chickens) or combinations), farm income (less than or equal to, or greater than the total median household income of USD 1400 per year); village size (less than and equal to, or greater than total median household number of 188); major income source (cropping, livestock sale, labour, trade and support by relatives) and previous occurrence of clinical FMD and ND on farms (yes/no).

6.4.3 Statistical analysis

A two-step approach was used to analyse the data: 1) initially descriptive statistics were produced to compare the proportion of farmers holding different perceptions on FMD and ND vaccination between livestock ownership groups; 2) then path analysis was used to investigate the causal factors influencing the willingness of farmers to conduct FMD and ND vaccination for each livestock ownership group.

All data analysis was conducted in STATA 14.0 (Stata Statistical Software, College Station, Stata Corporation, 2015) using a survey design approach by specifying PSU and SSU, sampling weights, sampling strata (townships), clustering (villages) and a finite population correction (Cochran 1977). Using a survey design approach ensured that correct standard errors were estimated (Deaton 1997, Nathan and Holt 1980, Pfeffermann 1993). Survey responses were first cross-tabulated and compared between livestock ownership groups. Pearson χ^2 statistics were converted into F statistics and standard errors and p-value were adjusted to the survey design (Koch, Freeman Jr et al. 1975, Rao and Scott 1984). Binomial logistic regression was used to describe the relationship between the demographic information (age, sex and experience of framers) and the knowledge of farmers on diseases (FMD and ND).

Details on path analysis modelling approach

Path analysis is based on multiple regression models that are used to identify the correlation between the exogenous variables representing the variables which are not causally dependent on any other variables, endogenous variables representing the outcome variables explained by the model and endogenous mediator variables representing the variables which intervene between exogenous variable and endogenous outcome variables (Acock 2013, Garson 2013). We used path analysis to identify the relationship between the perceptions of livestock farmers on the severity of FMD and ND, on the barriers and benefits of FMD and ND vaccination, the availability of information about vaccination to farmers, and the outcome of farmers' willingness to practise vaccination against FMD in cattle and small ruminants and ND in village chickens. Thus, we developed three different models separately for each livestock species: FMD vaccination on any farm owning cattle, FMD vaccination on any small ruminant-owning farm, and ND vaccination to any farm owning village chickens.

First, hypothesized pathways assuming causal relationships between exogenous variables and endogenous variables were developed. Hypothesized causal pathways focussed on nine hypotheses (Figure 6.1):

H1: Information availability (cues to action) may be associated with age, gender and duration of livestock reared.

H2: Information availability (cues to action) such as no information available about vaccination, information about vaccination provided through local authorities or other farmers or traders may be associated with knowledge of farmers about vaccination.

H3: Availability of vaccination may be associated with village size, due to factors such as infrastructure availability and likely contact with animal health services within or outside the village.

H4: Availability of funds to pay for vaccination may be associated with total household income.

H5: Major income source, such as cropping, livestock sale, labour, trade and supported by relatives, may be associated with household income.

H6: Household income per year in USD, barriers to vaccination and previous occurrence of clinical FMD and ND on farms may be influenced by the type of livestock ownerships (rearing single livestock species or with other species).

H7: Previous occurrence of clinical FMD and ND on farms may also influence the perceived impact of the disease.

H8: Perceived effectiveness of the vaccination may be associated with barriers to vaccination such as knowledge about vaccination, availability of vaccination and information availability about vaccination.

H9: Willingness of farmers to have their animals vaccinated may be predicted by perceived effectiveness of the vaccination, barriers to vaccination, perceived impact of the disease and type of different livestock ownerships (rearing single livestock species or with other species)

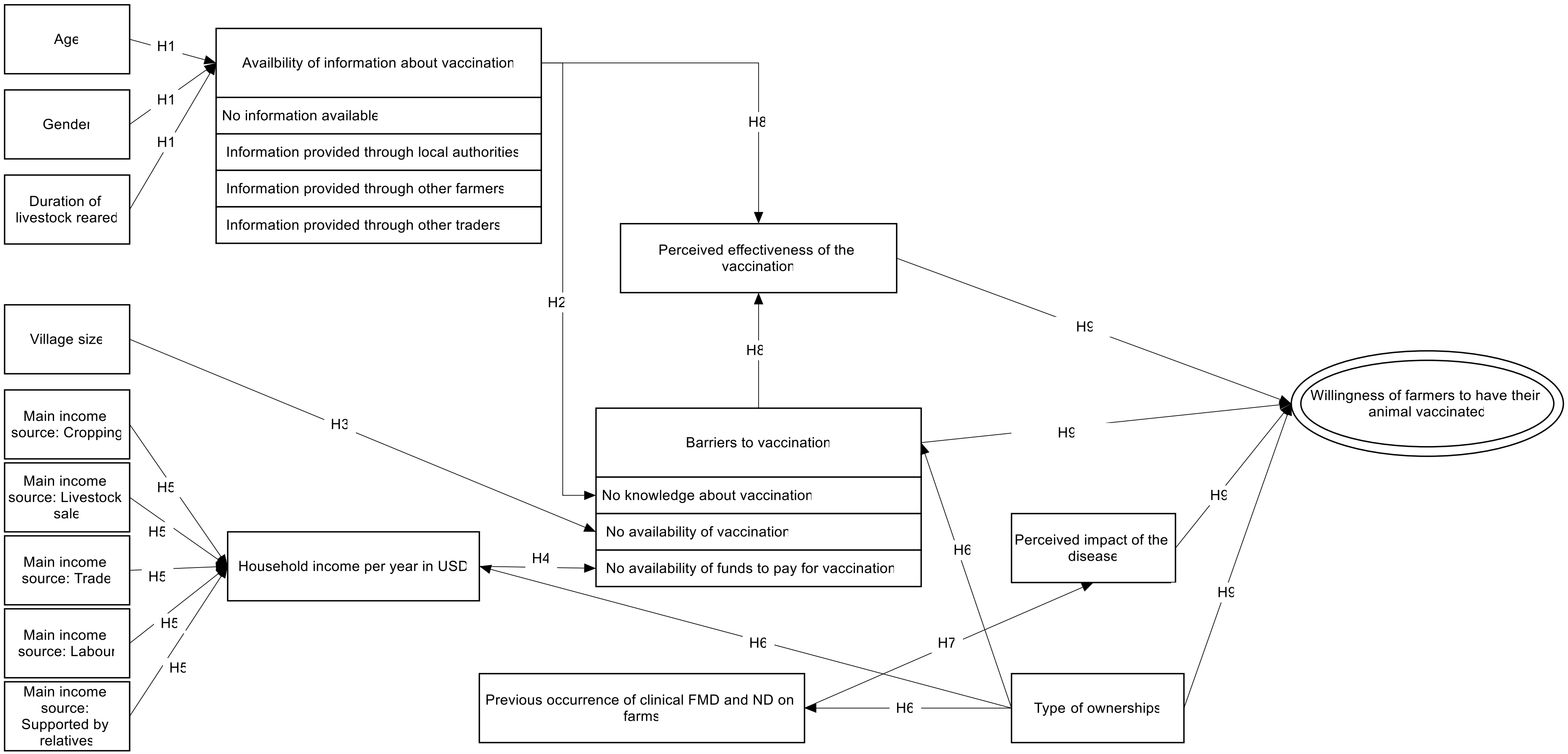


Figure 6.1 Hypothesized causal diagram to understand the perception of farmers rearing one species on vaccination practice

To inform the model building, we estimated tetrachoric correlation coefficients for all dichotomous variables for each livestock species separately and variables with significant correlation ($p<0.05$) were selected for the path analysis for each livestock species (i.e. some hypothetical pathways were removed). We used survey design approaches in the path analysis to account for primary sampling units (PSUs), secondary sampling units (SSUs) and sampling weights.

Path coefficients (also called standardized regression coefficient (beta)) were produced for direct, indirect and total effects. Direct effects represent the effect of one exogenous variable on an endogenous variable. Indirect effects represent the effect of one variable on another variable and thereby making changes to a third variable. Total effects are the sum of direct and indirect effects (Anonymous 2017, Duncan 1966, Li 1975). Only responses from farmers who stated that they were able to recognize FMD or ND were used in the path analysis. The fit of the path models was evaluated using standardized root mean squared residuals (SRMR), the coefficient of determination (CD) and the R-squared (Hu and Bentler 1998).

6.5 Results

6.5.1 Ability of farmers to recognize clinical signs for FMD and ND and their willingness to vaccinate against both diseases

The majority of ruminant farmers (cattle farmers: 95.8% of 328; small ruminant farmers: 80.1% of 303) and village chicken farmers (81.8% of 327) believed they were able to recognize clinical signs for FMD in ruminants and for ND in village chickens. Although only data of farmers who were able to recognize clinical signs for FMD and ND were used in the path models, we explored what demographic factors of farmers (age, gender, experience of rearing animals and type of ownerships) influenced the ability of farmers to recognize clinical signs for FMD and ND (Table 6.1). Male farmers rearing cattle were 14.6 times (95%CI: 1.6-130.8, $p = 0.018$) more likely to report they could recognize clinical signs of FMD than female farmers. No association between gender and ability to recognize FMD or ND signs was found for small ruminant and village chicken farmers. Other factors such as age, experience and type of ownership were not associated with recognizing clinical signs of FMD and ND.

Table 6.1 Frequency of demographic and farm details of farmers raising cattle, small ruminants or village chickens (Farmer aware of the diseases (FMD and ND) only) and village details *([a] = p<0.05 in F-statistics)*

Modifying factors	Details of survey questions	Categories	Proportion of farmer: Cattle farmer *(N = 366)*	Small ruminant farmer *(N = 252)*	Village chicken farmer *(N = 273)*	F-statistics (p-value)
Demographic information	*Gender of farmer:* By observation	Male	52.5 (44.4-60.5)	45.2 (37.3-53.3)	50.7 (43.1-58.3)	2.3 (p= 0.11)
		Female	47.5 (39.5-55.6)	54.8 (46.7-62.7)	49.3 (41.7-56.9)	
	Age of farmer: Median value (47 years old) was used as cut-off point	Below median	47.2 (39.1-55.4)	53.3 (43.5-62.9)	50.8 (43.4-58.2)	1.5 (p=0.24)
		Above median	52.8 (44.6-60.9)	46.7 (37.1-56.5)	49.2 (41.8-56.6)	
	Duration of livestock reared: Combine the four categories into two (below and above 5 years)	Less experience	8.1 (5.2-12.5)	Goat: 51.2 (42.0-60.3) Sheep: 85.4 (75.3-91.8)	25.8 (18.5-34.8)	31.9[a] (p<0.001)
		More experience	91.9 (87.5-94.8)	Goat: 48.8 (39.7-58.0) Sheep: 14.6 (8.2-24.8)	74.2 (65.2-81.5)	
Village details	*Village size:* Median value was used as cut-off point	≤188 hh	34.7 (22.8-48.9)	34.5 (22.4-49.0)	35.7 (23.5-50.1)	0.1 (p=0.87)
		>188 hh	65.3 (51.1-77.2)	65.6 (51.0-77.7)	64.3 (49.9-76.5)	
Household income	*Total income per year in USD:* How much money did your household earn over the last 12 months?: Median value across all the farms was used as cut-off point	≤1400 USD per year	44.0 (36.7-51.7)	46.4 (38.0-54.9)	44.0 (35.0-53.3)	0.4 (p=0.65)
		>1400 USD per year	56.0 (48.4-63.3)	53.6 (45.1-62.0)	56.0 (46.7-65.0)	
	Major income source: Which of the following businesses contribute the largest amount of money to your household in a typical year? (Each type was dichotomised in the analysis)	Cropping	53.3 (46.1-60.4)	27.8 (21.1-35.7)	39.6 (31.3-48.5)	7.5[a] (p<0.001)
		Livestock sale	19.1 (14.3-25.0)	40.9 (32.5-49.8)	25.5 (17.9-35.0)	
		Labour	11.8 (6.4-20.8)	13.3 (7.0-23.8)	14.8 (8.7-24.1)	
		Trade	3.9 (2.1-7.1)	7.7 (4.3-13.2)	7.4 (4.3-12.7)	
		Support by relatives	12.0 (7.6-18.3)	10.4 (5.8-17.7)	12.7 (7.3-21.0)	
Previous occurrence of clinical FMD and ND on farms	Have you seen the following clinical signs in your farm? Dichotomized for each category	Sore or abnormal hoof, foot or leg causing abnormal movement and other physical abnormalities (i.e. FMD signs)	21.2 (16.7-26.5)	39.8 (30.6-49.7)	N/A	8.8[a] (p<0.001)

Modifying factors	Details of survey questions	Categories	Proportion of farmer			F-statistics (p-value)
			Cattle farmer *(N = 366)*	**Small ruminant farmer *(N = 252)***	**Village chicken farmer *(N = 273)***	
		Twisted head and neck and other physical abnormalities (i.e. ND signs)	N/A	N/A	35.7 (27.7-44.7)	

Amongst only farmers who reported being able to recognize FMD or ND signs, the willingness to practise vaccinations differed between the three main livestock farmer groups ($p<0.001$), with 88% of cattle farmers, 84% of small-ruminant farmers and 71% of village chicken farmers being willing to vaccinate their animals (Table 6.2). Within the seven different combinations of livestock species reared by households (Figure 6.2), the proportion reporting willingness to conduct FMD or ND vaccinations did not differ significantly ($p>0.05$).

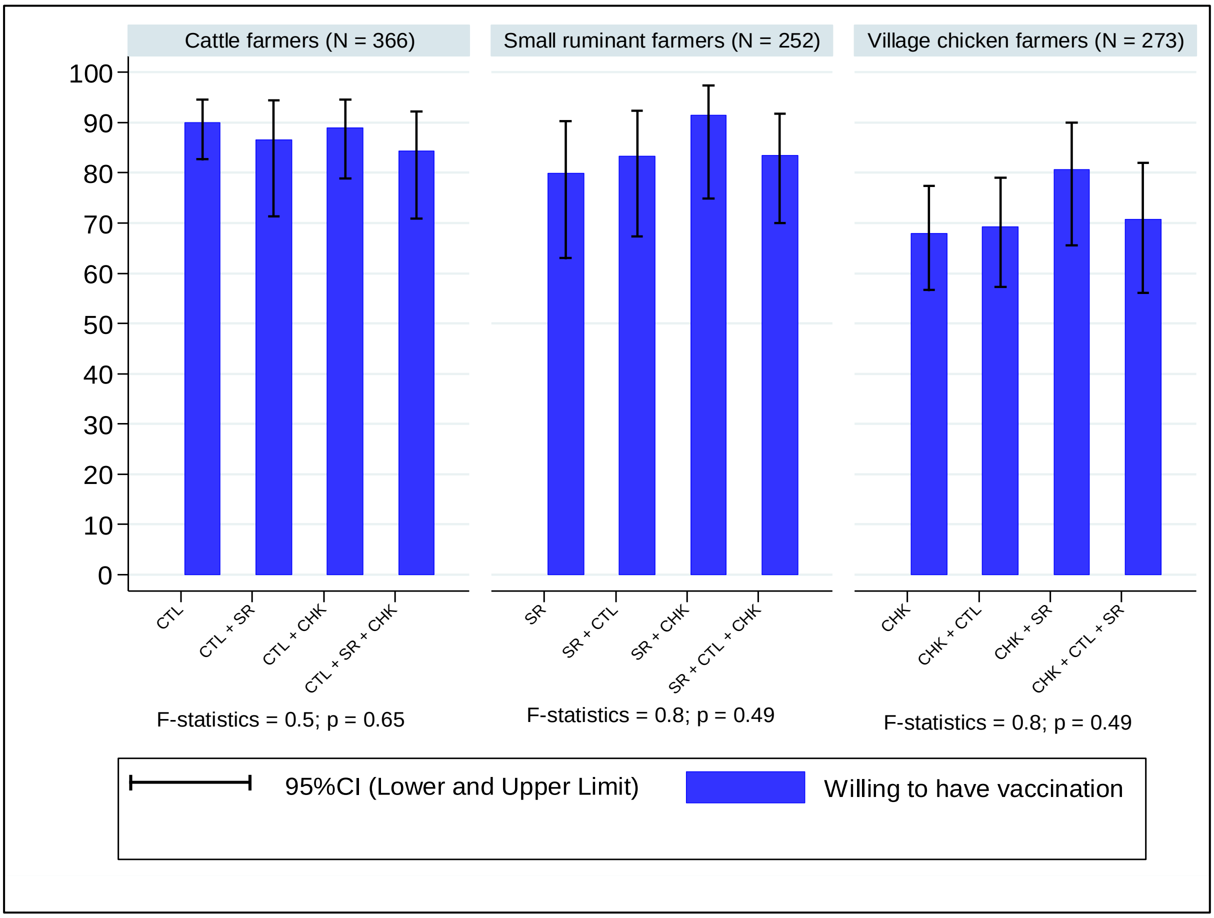


Figure 6.2 Proportion of farmers reporting their willingness to conduct their farm animal vaccination

Focusing in the rest of the analysis on the three main livestock farmer groups, there were significant differences in the barriers to practise vaccination, availability of information about disease prevention and vaccination in the villages and previous occurrences of FMD and ND signs ($p<0.05$). About 17.0% of cattle, 15.4% of village chickens, but only 2.3% of small ruminant owners, indicated that the non-availability of vaccinations in the villages was the major constraint to vaccinations ($p<0.001$), while in contrast twice as many small ruminant farmers compared to cattle and village chicken farmers indicated they had no knowledge about vaccinations and no funds to conduct vaccinations (Table 6.2).

About 19.4% of cattle, 38.3% of small ruminants, but 57.7% of village chicken owners indicated that no information is provided to them about the prevention of major infectious diseases ($p<0.001$). Local authorities were the main provider for information on disease prevention and vaccinations (although less frequent on ND prevention in village chickens), while traders seemed to be an important additional source of information about FMD vaccinations for small ruminant farmers. The proportion of farmers who reported severe impacts of disease on the sale of animals was higher for village chickens (91.5%) and small ruminant farmers (81.0%) compared to cattle farmers (75.2%) ($p<0.001$). This is also reflected in small ruminant and village chicken farmers reporting previous occurrence of clinical FMD and ND signs on their farms compared to cattle households (Table 6.2).

Table 6.2 Frequency of perceptions and practices of FMD or ND vaccination amongst farmers raising cattle, small ruminants or village chickens (Farmer aware of the diseases (FMD and ND) only) *(* = FMD in cattle and small ruminants and ND in village chickens; ** = FMD vaccination in cattle and small ruminants and ND vaccination in village chickens; [a] = p<0.05 in F-statistics)*

HBM components and modifying factors	Details of survey questions	Categories	Proportion of farmers: Cattle farmers *(N = 366)*	Small ruminant farmers *(N = 252)*	Village chicken farmers *(N = 273)*	F-statistics (p-value)
Perceived severity	***Perceived impact of the diseases:*** Do you think the incidence of the disease* in your farm animals can cause loss in marketing and trading (i.e. reduce sale or sale prices or traders are not willing to buy animals)?	FMD for cattle and small ruminants; and ND for village chickens	75.2 (69.1-80.4)	81.0 (74.8-86.0)	91.5 (85.6-95.1)	11.1[a] (p<0.001)
Perceived effectiveness	***Perceived effectiveness of vaccination:*** Do you think that the vaccination** can prevent the following disease* occurrence? (Dichotomized for each categories)	FMD for cattle and small ruminants; and ND for village chickens	83.2 (78.1-87.4)	83.0 (77.0-87.7)	72.8 (65.6-78.9)	1.7 (p=0.19)
Perceived barrier	***Barriers to vaccination:*** What are the main barriers or obstacles to conduct vaccination**? (Dichotomized for each categories)	No availability of fund to pay for vaccination	9.1 (6.7-12.3)	12.9 (9.0-18.1)	6.6 (3.7-11.6)	4.2[a] (p<0.05)
		No knowledge about vaccination	7.1 (4.3-11.7)	18.7 (13.4-25.7)	5.3 (3.0-9.2)	16.3[a] (p<0.001)
		No availability of vaccination	17.5 (12.6-23.7)	2.3 (0.9-5.7)	15.4 (10.4-22.0)	26.1[a] (p<0.001)
Cue to action	***Availability of information about vaccination:*** From whom did you receive some guidance or instructions about vaccination** programme? (Dichotomized for each categories)	No information availability	19.4 (14.7-25.3)	38.3 (30.8-46.3)	57.7 (50.9-64.3)	38.4[a] (p<0.001)
		Information provided through local authorities	75.0 (68.0-80.9)	48.0 (38.5-57.6)	35.3 (28.6-42.6)	32.8[a] (p<0.001)
		Information provided through other farmers	4.3 (2.2-7.9)	6.5 (3.5-11.7)	5.2 (2.8-9.6)	0.98 (p=0.38)
		Information provided through traders	1.3 (0.5-3.4)	7.3 (4.5-11.7)	1.7 (0.4-6.7)	6.7[a] (p<0.05)

HBM components and modifying factors	Details of survey questions	Categories	Proportion of farmers			F-statistics (p-value)
			Cattle farmers *(N = 366)*	**Small ruminant farmers** *(N = 252)*	**Village chicken farmers** *(N = 273)*	
Likelihood of practicing vaccination	***Willingness of farmers to have their animals vaccinated:*** Would you like to practise the vaccination** in your farm animal? (Dichotomized for each categories)	FMD vaccination	88.0 (81.6-92.4)	83.9 (74.2-90.4)	N/A	10.6[a] (p<0.001)
		ND vaccination	N/A	N/A	71.3 (64.6-77.2)	

6.5.2 Factors that influence farmers' willingness to vaccinate their livestock against FMD and ND

6.5.2.1 Correlations between farmers' perceptions about FMD and ND vaccinations, types of livestock reared, farmers' demographics and farmers' willingness to conduct vaccinations

Tetrachoric correlations between farmers' perceptions about FMD and ND vaccinations, types of livestock reared, farmers' demographics and farmers' willingness to conduct vaccination are shown in Tables 6.3-6.5. Similar correlations were observed for all three-livestock species: information available through local authorities was negatively correlated with no knowledge about vaccination ($r = -0.4$, $p<0.05$ for cattle; $r = -0.1$, $p>0.05$ for small ruminants; $r = -1.0$, $p<0.05$ for village chickens). No information available was negatively correlated with perceived impact of disease (i.e. FMD for cattle and small ruminants, and ND for village chickens) ($r = -0.2$, $p<0.05$ for cattle; $r = -0.3$, $p<0.05$ for small ruminants; and $r = -0.3$, $p>0.05$ for village chickens) and positively correlated with no knowledge about vaccination ($r = 0.5$, $p<0.05$ for cattle; $r = 0.03$, $p>0.05$ for small ruminants; $r = 0.4$, $p<0.05$ for village chickens). Perceived impact of disease was positively correlated with perceived effectiveness of vaccinations ($r = 0.2$, $p<0.5$ for cattle; $r = 0.3$, $p<0.05$ for small ruminants; $r = 0.5$, $p<0.05$ for village chickens) while no knowledge about vaccination was negatively correlated with perceived effectiveness of vaccinations ($r = -0.5$, $p<0.05$ for cattle; $r = -0.4$, $p<0.05$ for small ruminants; $r = -0.5$, $p<0.05$ for village chickens). Village size was positively correlated with both perceived effectiveness of vaccination ($r = 0.3$, $p<0.05$ for cattle; $r = 0.2$, $p>0.05$ for small ruminants; $r = 0.2$, $p>0.05$ for village chickens) and willingness of farmers to have their animals vaccinated ($r = 0.3$, $p<0.05$ for cattle; $r = 0.3$, $p<0.05$ for small ruminants; $r = 0.2$, $p>0.05$ for village chickens) (Tables 6.3-6.5).

Table 6.3 Correlation coefficient of health belief criteria of cattle farmers on FMD vaccination using tetrachoric correlation coefficient (* *p*<0.05)

Sub-table 1:

		1	2	3	4	5	6	7	8	9	10	11
1	Perceived impact of FMD	1.0000										
2	No availability of funds to pay for vaccination	0.2812	1.0000									
3	No knowledge about vaccination	-0.264	-1	1.0000								
4	No availability of vaccination	-0.1295	**-1.0000***	**-1.0000***	1.0000							
5	Information through farmers	0.0495	-0.0196	-1	0.0524	1.0000						
6	Information through local authorities	0.1215	0.1326	**-0.3788***	-0.019	**-1.0000***	1.0000					
7	Information through traders	1.0000	-1.0000	-1.0000	-1.0000	-1.0000	**-1.0000***	1.0000				
8	No information available	**-0.2164***	-0.1098	**0.5163***	0.0495	**-1.0000***	**-1.0000***	-1.0000	1.0000			
9	Rearing CRL	-0.1004	-0.0914	0.2181	**-0.2146***	-0.1407	0.1561	-0.0415	-0.1222	1.0000		
10	Rearing CTL + SR	0.1456	-0.0117	0.0179	0.2205	-0.0345	-0.2399*	0.1952	**0.2565***	**-1.0000***	1.0000	
11	Rearing CTL + CHK	0.1446	-0.0691	-0.243	0.0821	0.0803	0.1243	-0.2224	-0.1565	**-1.0000***	**-1.0000***	1.0000
12	Rearing CTL + SR + CHK	-0.1482	0.1802	-0.0372	-0.0431	0.0852	-0.122	0.0851	0.0936	**-1.0000***	**-1.0000***	**-1.0000***
13	Major income: Livestock sale	0.0858	-0.0813	-0.1378	0.124	0.1549	-0.1546	0.3018	0.0513	**-0.4164***	**0.4271***	-0.147
14	Major income: Cropping	0.0438	-0.1715	-0.0696	0.0578	0.016	0.1113	-0.4362	-0.0717	**0.2072***	**-0.2202***	-0.0005
15	Perceived effectiveness	**0.2348***	0.1271	**-0.4670***	-0.0882	0.1073	**0.3265***	1.0000	**-0.4322***	-0.0458	-0.1576	0.2077
16	Willingness of farmers to have their animals vaccinated	**0.4242***	0.0979	**-0.7543***	**0.3290***	0.2415	0.1688	-0.0441	**-0.2590***	-0.0598	0.0233	0.0783
17	Previous occurrence of clinical FMD on farms	-0.0298	0.2214	-0.0011	0.0059	-0.0348	0.0821	-1.0000	-0.0312	-0.0133	-0.0277	0.0156
18	Village size	-0.1069	**0.2922***	-0.0208	**0.2096***	-0.1037	-0.0319	-0.2637	0.131	-0.1800*	0.0801	-0.0273
19	Age	0.0825	0.1683	-0.0133	**0.2194***	**-0.3934***	**0.2313***	0.0431	-0.118	0.0328	-0.1249	0.0058
20	Gender	**0.2048***	-0.1915	-0.036	**0.2693***	-0.0023	0.0136	0.0253	-0.0198	-0.0664	-0.0309	0.0917
21	Duration of cattle reared	-0.0424	-0.2627	-0.1029	0.0635	-0.0158	0.1327	-0.3434	-0.0676	0.0323	**-0.2863***	**0.3069***

Sub-table 2:

		12	13	14	15	16	17	18	19	20	21
12	Rearing CTL + SR + CHK	1.0000									
13	Major income: Livestock sale	0.1998	1.0000								
14	Major income: Cropping	-0.0736	**-1.0000***	1.0000							
15	Perceived effectiveness	-0.0379	-0.1661	0.051	1.0000						
16	Willingness of farmers to have their animals vaccinated	-0.0348	0.0386	0.0854	**0.5478***	1.0000					
17	Previous occurrence of clinical FMD on farms	0.019	0.0063	-0.0591	0.0109	-0.0289	1.0000				
18	Village size	0.1891	-0.0621	0.0786	**0.2888***	**0.2674***	-0.013	1.0000			
19	Age	0.0531	-0.133	**0.2050***	**0.2471***	0.1524	-0.1305	**0.2487***	1.0000		
20	Gender	-0.0034	-0.0007	0.1486	0.1068	0.178	0.0178	0.012	0.1584	1.0000	
21	Duration of cattle reared	-0.0816	-0.0336	**0.3201***	-0.1964	0.1157	-0.0618	0.1405	0.1783	0.1107	1.0000

Table 6.4 Correlation coefficient of health belief criteria of small ruminant farmers on FMD vaccination using tetrachoric correlation coefficient (* *p<0.05*)

Sub-table 1

		1	2	3	4	5	6	7	8	9	10	11
1	Perceived impact of FMD	1.0000										
2	No availability of funds to pay for vaccination	0.3645	1.0000									
3	No knowledge about vaccination	-0.2073	**-1.0000***	1.0000								
4	No availability of vaccination	-0.0761	-1.0000	-1.0000	1.0000							
5	Information through farmers	-0.0252	0.0252	-0.1251	-1.0000	1.0000						
6	Information through local authorities	0.2349	**0.3050***	-0.0828	0.1258	**-1.0000***	1.0000					
7	Information through traders	0.1733	-0.2182	0.2328	-1.0000	-1.0000	**-1.0000***	1.0000				
8	No information available	**-0.2879***	-0.2836	0.0276	0.0262	**-1.0000***	**-1.0000***	**-1.0000***	1.0000			
9	Rearing SR	0.0335	**0.2855***	-0.1022	0.0471	0.2128	-0.049	**0.4782***	-0.2194	1.0000		
10	Rearing SR + CTL	0.0677	-0.1617	0.1723	-0.1285	-0.1035	-0.0265	-0.3321	0.1516	**-1.0000***	1.0000	
11	Rearing SR + CHK	0.2499	**-0.4367***	-0.0572	-1.0000	-0.2242	-0.0681	-0.102	0.1623	**-1.0000***	**-1.0000***	1.0000
12	Rearing SR + CTL + CHK	-0.2304	0.0283	-0.0005	0.2282	-0.03	0.1194	-0.3283	-0.014	**-1.0000***	**-1.0000***	**-1.0000***
13	Major income: Livestock sale	0.0726	-0.0926	-0.1009	0.278	-0.1273	-0.1903	0.2004	0.1654	0.1538	0.0234	0.1608
14	Major income: Cropping	0.0345	0.1215	0.1051	-0.0858	-0.042	0.2065	-0.339	-0.1019	**-0.2642***	0.1477	**-0.5093***
15	Perceived effectiveness	**0.2897***	0.1523	**-0.3681***	0.0487	-0.1282	**0.2758***	-0.1727	-0.1736	0.0388	-0.1345	-0.0252
16	Willingness of farmers to have their animals vaccinated	**0.5340***	0.2057	-0.2561	1.0000	1.0000	**0.3101***	0.015	**-0.4017***	-0.0703	0.0524	0.2721
17	Previous occurrence of clinical FMD on farms	-0.0884	-0.0584	-0.1014	-0.3287	0.2715	-0.1495	-0.0064	0.0712	0.1468	-0.1453	0.1103
18	Village size	**-0.2477***	0.2622	0.0491	0.425	-0.3278	**0.3198***	**-0.4936***	-0.0637	-0.118	0.0758	-0.2035
19	Age	-0.0612	-0.0058	0.063	0.1919	-0.2222	0.185	0.0202	-0.1384	-0.0875	-0.0758	-0.1905
20	Gender	0.0229	-0.1966	0.1275	0.1636	0.205	-0.0317	-0.2515	0.06	-0.1166	-0.0046	-0.0119
21	Duration of sheep reared	-0.131	-0.0519	**-0.3155***	**0.7664***	0.0571	0.1153	**-1.0000***	-0.0081	-0.1567	-0.0851	0.0031
22	Duration of goat reared	-0.0612	**-0.3152***	**0.2465***	-0.425	0.2362	-0.1367	**0.3301***	-0.0518	-0.058	0.0795	-0.1014

Sub-table 2

		12	13	14	15	16	17	18	19	20	21	22
12	Rearing SR + CTL + CHK	1.0000										
13	Major income: Livestock sale	**-0.2998***	1.0000									
14	Major income: Cropping	**0.4228***	**-1.0000***	1.0000								
15	Perceived effectiveness	0.0923	-0.083	0.0534	1.0000							
16	Willingness of farmers to have their animals vaccinated	-0.1214	0.111	-0.0503	**0.5150***	1.0000						
17	Previous occurrence of clinical FMD on farms	-0.1226	**0.2402***	-0.0792	**0.2875***	-0.0352	1.0000					
18	Village size	0.2076	-0.1258	**0.3513***	0.2312	**0.3006***	**-0.3032***	1.0000				
19	Age	**0.2769***	-0.0995	**0.2181***	-0.0491	-0.1976	0.0504	0.1812	1.0000			
20	Gender	0.1327	0.1177	0.0125	-0.0996	0.1021	0.1314	-0.1222	**0.2281***	1.0000		
21	Duration of sheep reared	0.2101	0.03	**0.2744***	0.1821	0.109	**0.3487***	0.1049	**0.2951***	0.1733	1.0000	
22	Duration of goat reared	0.0676	**0.2903***	-0.1722	-0.0949	0.0108	0.1643	-0.0887	-0.0736	-0.0391	**-0.4799***	1.0000

Table 6.5 Correlation coefficient of health belief criteria of village chicken farmers on ND vaccination using tetrachoric correlation coefficient (* p<0.05)

Sub-table 1

		1	2	3	4	5	6	7	8	9	10
1	Perceived impact of FMD										
2	No availability of funds to pay for vaccination	1.0000	1.0000								
3	No knowledge about vaccination	-0.2135	-1.0000	1.0000							
4	No availability of vaccination	-0.1299	-1.0000	-1.0000	1.0000						
5	Information through farmers	0.0054	0.2511	-1.0000	0.1439	1.0000					
6	Information through local authorities	0.2058	0.1318	**-1.0000***	0.1242	**-1.0000***	1.0000				
7	Information through traders	1.0000	-1.0000	1.0000	-1.0000	-1.0000	-1.0000	1.0000			
8	No information available	-0.3175	-0.0593	**0.3573***	0.1952	**-1.0000***	**-0.6823***	-1.0000	1.0000		
9	Rearing CHK + CTL	0.0129	-0.1070	0.0253	-0.1652	-0.0804	0.0160	-1.0000	**-0.4989***	1.0000	
10	Rearing CHK + SR	0.1616	-0.1198	0.1040	-0.0340	-0.2373	-0.0029	1.0000	**0.3579***	**-1.0000***	1.0000
11	Rearing CHK + CTL +SR	-0.1192	0.1895	-0.1162	0.1978	0.2217	-0.0154	-1.0000	**0.2610***	**-1.0000***	**-1.0000***
12	Major income: Livestock sale	-0.2412	0.2176	0.1162	-0.1063	0.2283	-0.0777	1.0000	0.1909	**-0.4062***	**0.4197***
13	Major income: Cropping	**0.4787***	-0.0340	-0.3636	0.2246	0.0953	0.0858	-1.0000	-0.1436	**0.3507***	**-0.6612***
14	Perceived effectiveness	**0.4863***	0.0813	**-0.4815***	0.2449	0.0067	0.2497	1.0000	-0.1952	0.0656	-0.0387
15	Willingness of farmers to have their animals vaccinated	**0.3649***	0.1262	**-0.4000***	0.2113	0.1794	**0.4234***	1.0000	-0.0520	-0.0601	0.2011
16	Previous occurrence of clinical ND on farms	0.3178	-0.2760	0.0621	-0.0503	0.0621	0.1723	-1.0000	-0.1139	-0.0675	0.1039
17	Village size	-0.1224	0.0541	-0.0760	0.1499	0.0299	0.1532	-1.0000	-0.0419	-0.0560	-0.2421
18	Age	-0.0872	0.0111	-0.0316	0.1070	-0.2431	0.0383	-1.0000	-0.1081	0.1132	-0.2272
19	Gender	**0.5158***	-0.1107	-0.2733	0.3730*	-0.0633	0.1772	-1.0000	-0.1627	0.1642	-0.1795
20	Duration of village chicken reared	0.2104	-0.0709	-0.0410	0.1134	-0.0410	0.1643	1.0000	-0.1060	0.2345	-0.2515

Sub-table 2

		11	12	13	14	15	16	17	18	19	20
11	Rearing CHK + CTL +SR	1.0000									
12	Major income: Livestock sale	0.0920	1.0000								
13	Major income: Cropping	0.0685	**-1.0000***	1.0000							
14	Perceived effectiveness	-0.0422	-0.1929	0.1767	1.0000						
15	Willingness of farmers to have their animals vaccinated	-0.0758	-0.0905	0.2071	**0.7922***	1.0000					
16	Previous occurrence of clinical ND on farms	-0.0057	-0.0362	-0.1368	-0.0081	-0.0022	1.0000				
17	Village size	**0.2465***	**-0.3288***	**0.3321***	0.1506	0.2171	-0.2003	1.0000			
18	Age	0.0468	-0.1082	**0.2657***	-0.0074	-0.0424	**-0.3398***	**0.2885***	1.0000		
19	Gender	-0.0453	-0.0020	0.1368	0.2312	0.2331	0.1147	**0.2343***	0.1657	1.0000	
20	Duration of village chicken reared	-0.0525	0.0248	0.1774	0.0862	0.0310	0.0517	0.0924	0.1510	**0.3190***	1.0000

6.5.2.2 Path analysis modelling to understand factors influencing farmers' willingness to vaccinate cattle against FMD

Perceived effectiveness of the FMD vaccine was a crucial factor for cattle farmers to implement FMD vaccinations (β= 0.3 [0.1-0.5], p= 0.018), while poor knowledge about the use of vaccinations to control FMD reduced the overall willingness to conduct vaccinations (β= -0.4 [-0.7- -0.2], p= 0.000), but also reduced farmers' beliefs in the effectiveness of the FMD vaccine (β= -0.2 [-0.4- -0.1], p= 0.009). In addition, an understanding of farmers that FMD can result in severe economic losses increased their belief in the effectiveness of FMD vaccinations (β= 0.1 [0.01-0.3], p= 0.034). As expected, increased availability of information about FMD control increased farmers' knowledge about the purpose and use of FMD vaccinations (β= 0.2 [0.1-0.3], p= 0.002), while unavailability of vaccination campaigns in a village reduced farmers' knowledge about the purpose and use of FMD vaccinations (β= 0.1 [0.03-0.1], p= 0.039). Thus, both, the cattle farmers' knowledge about FMD control (β= -0.4 [-0.7- -0.2], p= 0.000) and the availability of FMD vaccine (β= 0.04 [-0.1-0.2], p= 0.416) are key determinants to improve cattle farmers' willingness to practise FMD control.

In larger villages, total income from cattle production was higher (β= 0.1 [0.01-0.2], p= 0.31), resulting in more funds being available (β= -0.1 [-0.2-0.01], p= 0.064) to cattle famers to conduct FMD vaccination, which in turn also positively impacted on the availability of FMD vaccines in villages (β= -0.2 [-0.3- -0.1], p=0.001). The latter might be a result of cattle farmers with larger incomes 'requesting' FMD vaccination campaigns to be conducted in their villages (β= 0.02 [-0.1-0.1], p= 0.645) (Figures 6.3-6.4).

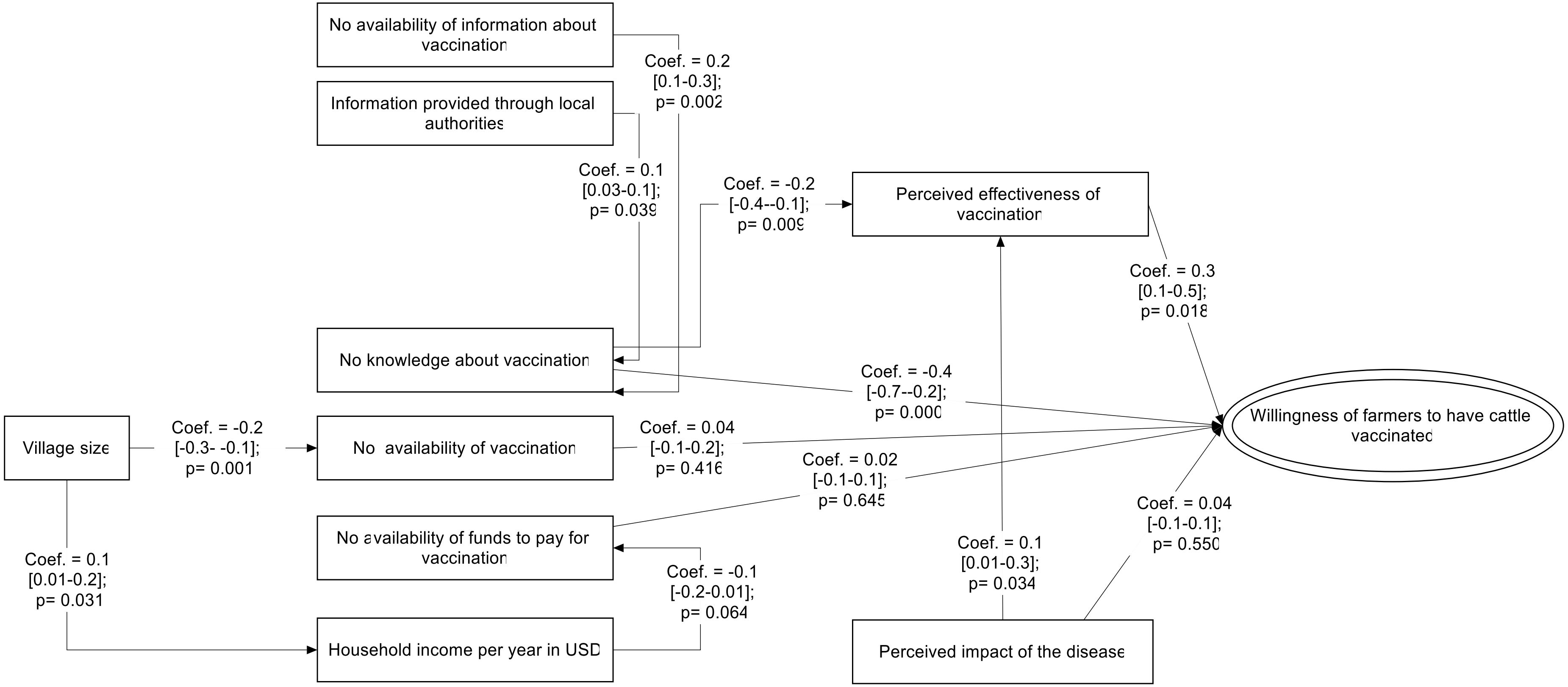


Figure 6.3 Causal path modelling approach to understand farmers' perception on Foot and Mouth Disease (FMD) vaccination practice in cattle production indicating Coef: path coefficient with confidence limit; p: p-value

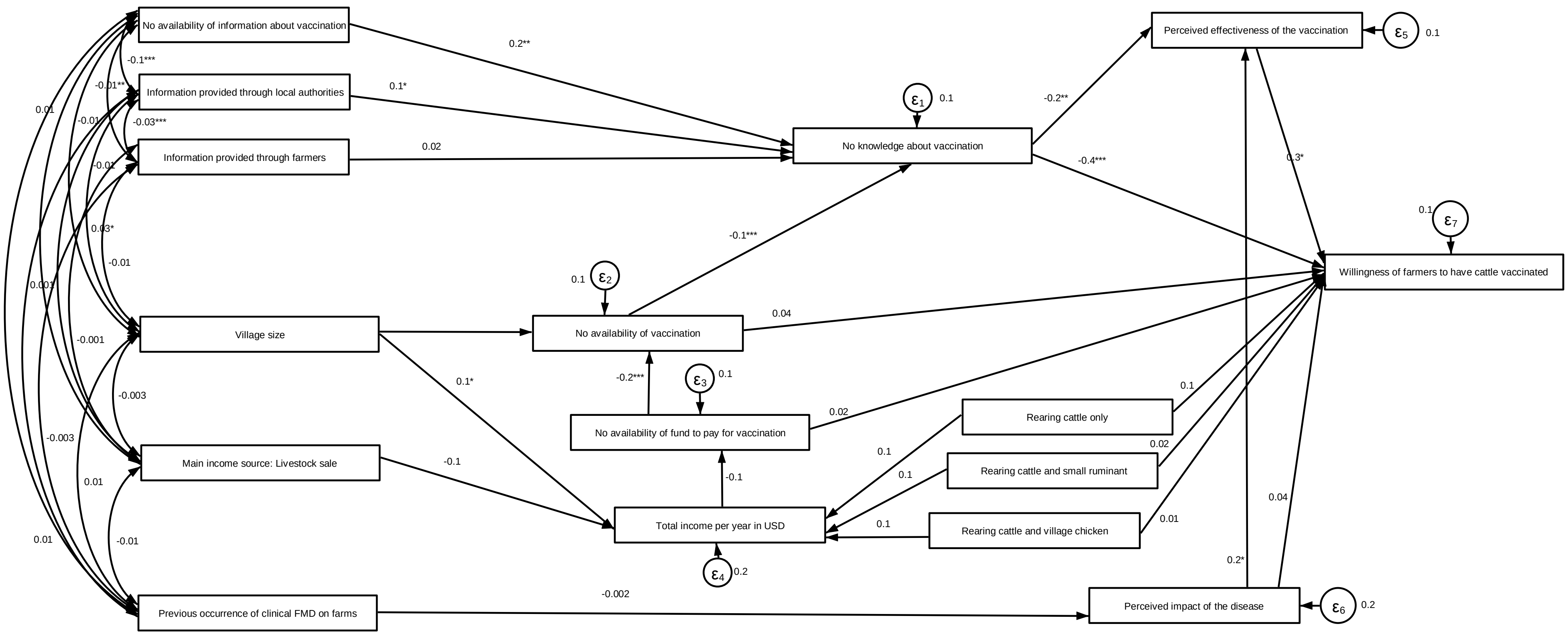


Figure 6.4 The complete path model analysis to understand the factors affecting the willingness of farmers to have cattle vaccinated

The final path model describing the perceptions of small ruminant farmers about having their animals vaccinated had a reasonable fit with a SRMR of 0.043 and CD of 0.122.

6.5.2.3 Path analysis modelling to understand factors influencing farmers' willingness to vaccinate small ruminants against FMD

The perceived economic impact on sales was the driving factor for small ruminant farmers to implement FMD vaccinations ($\beta = 0.2$ [0.1-0.3], $p = 0.005$), while the non-availability of information about FMD vaccination was the major limiting factor ($\beta = -0.2$ [-0.3- -0.03], $p = 0.014$) (Figures 6.5-6.6).

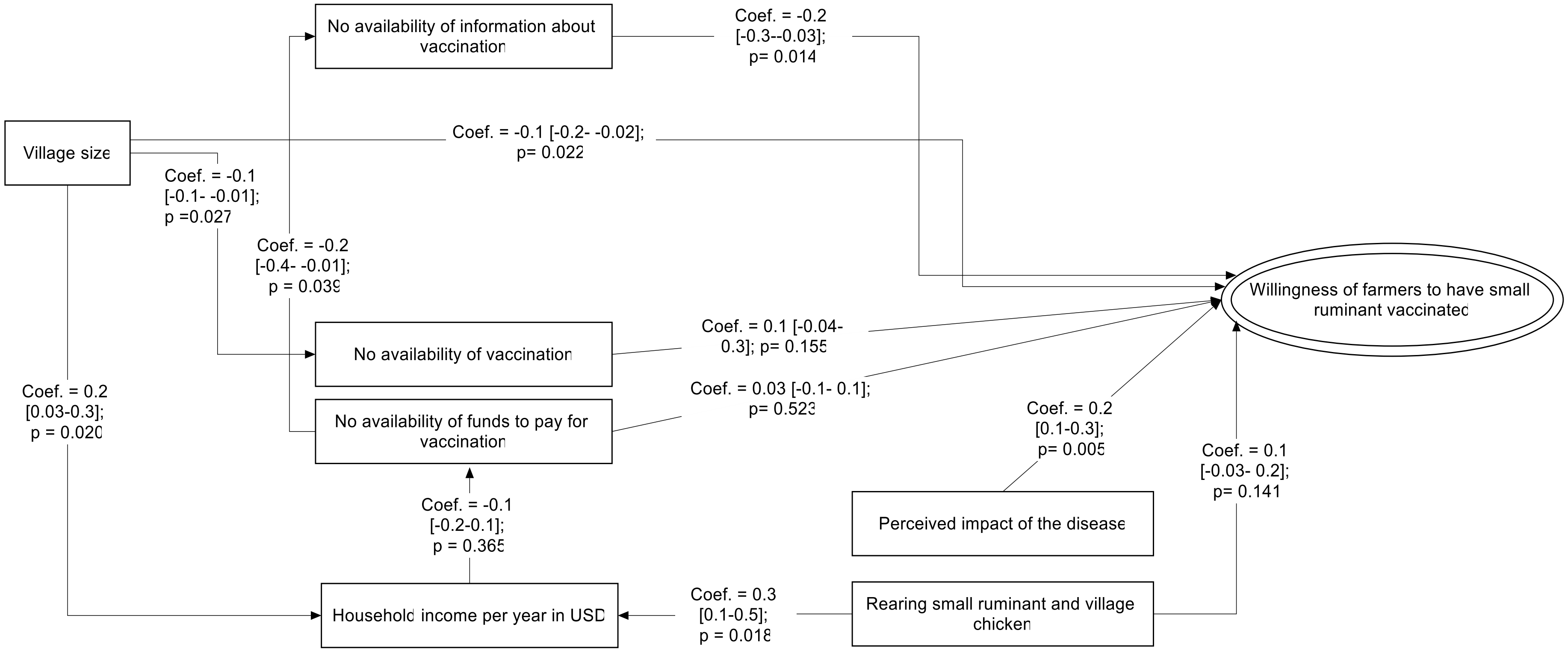


Figure 6.5 Causal path modelling approach to understand farmers' perception on Foot and Mouth Disease (FMD) vaccination practice in small ruminant production indicating Coef: path coefficient with confidence limit; p: p-value

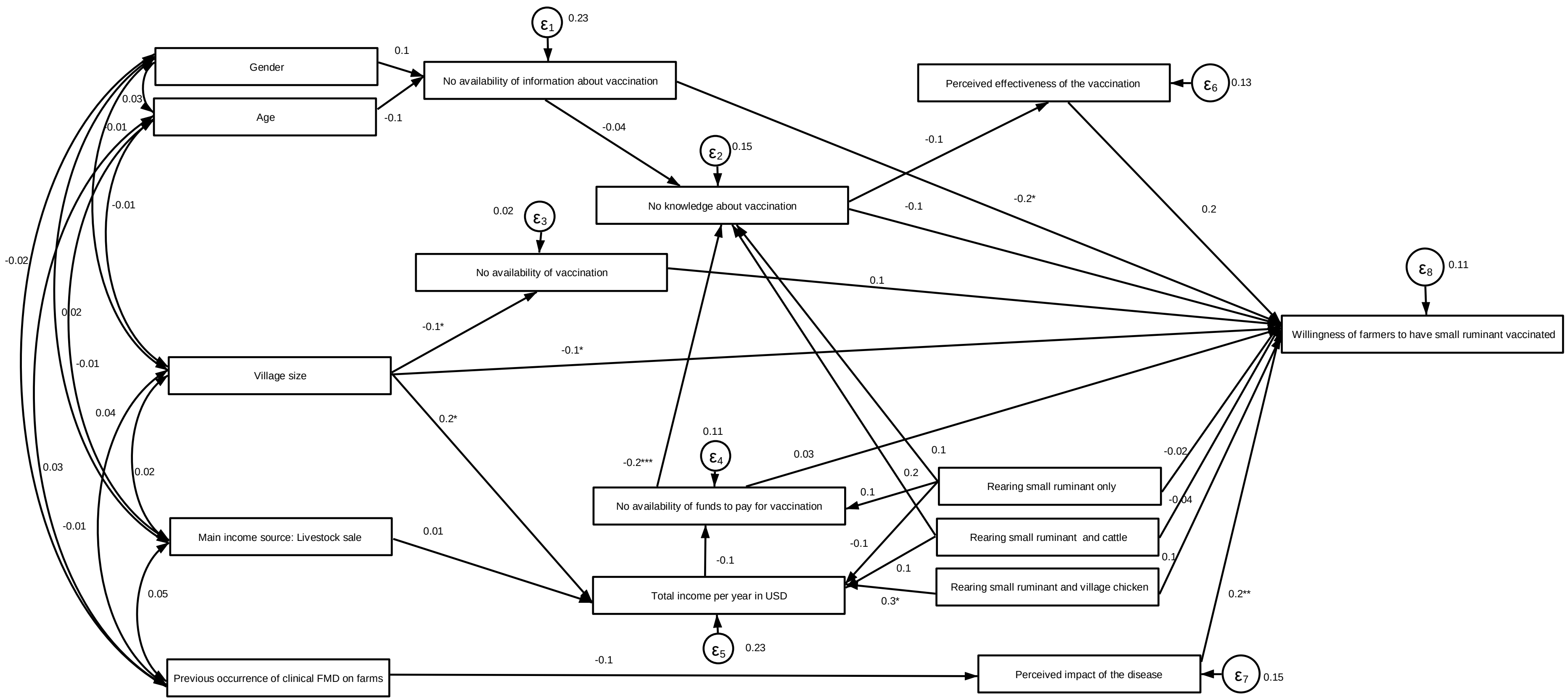


Figure 6.6 The complete path model analysis to understand the factors affecting the willingness of farmers to have small ruminants vaccinated

Similarly, village size had significant indirect impact, as in larger villages greater availability of vaccination was observed (β= -0.1 [-0.1- -0.01], p= 0.027), but also the income of small ruminant farmers was increased (β= 0.2 [0.03-0.3], p= 0.020). No availability of funds to conduct vaccinations also reduced the availability of information about vaccination (β= -0.2 [-0.4- -0.01], p= 0.039) - perhaps famers with limited funds were less likely to access information about FMD vaccinations, perhaps assuming that they cannot afford FMD vaccination or any preventive actions in general (β= -0.2 [-0.3- -0.03], p= 0.014).The perceived effectiveness of FMD vaccine was not a factor impacting on the willingness of small ruminant farmers to conduct FMD vaccinations.

Rearing small ruminants together with village chickens increased a small ruminants farmer's income (β= 0.3 [0.1-0.5], p= 0.018), although the overall impact of raising these two species together on the willingness to conduct FMD vaccinations is unclear (β= 0.1 [-0.03-0.2], p= 0.141).

The final path model describing the willingness of small ruminant farmers to have their animals vaccinated had a reasonable fit with a SRMR of 0.049 and CD of 0.187. The modification index suggested to include a path between village size and the willingness to conduct FMD vaccinations in the final path model.

6.5.2.4 Path analysis modelling to understand factors influencing farmers' willingness to vaccinate village chickens against ND

Similar to cattle households, the perceived effectiveness of the vaccine (ND) was the driving force for village chicken farmers to implement vaccinations (β= 0.5 [0.3-0.6], p<0.001), while an understanding of the economic losses of ND outbreaks increased farmers beliefs in the effectiveness of the ND vaccine (β= 0.3 [0.1-0.6], p= 0.004). Unavailability of information about ND vaccination reduced willingness of farmers for ND vaccination (β= -0.2 [-0.3- -0.1], p= 0.010), but was also directly related to village chicken farmers' knowledge about the purpose and use of ND vaccinations (β= 0.1 [0.01-0.1], p= 0.016). And once again, in smaller villages the availability of ND vaccine was limited (β= -0.1 [-0.2- -0.04], p= 0.005) which directly impacted on the willingness of farmers to conduct ND vaccinations (β= 0.2 [0.04-0.3], p= 0.008) (Figures 6.7-6.8). The final path had a reasonable fit with a SRMR of 0.038 and CD of 0.216.

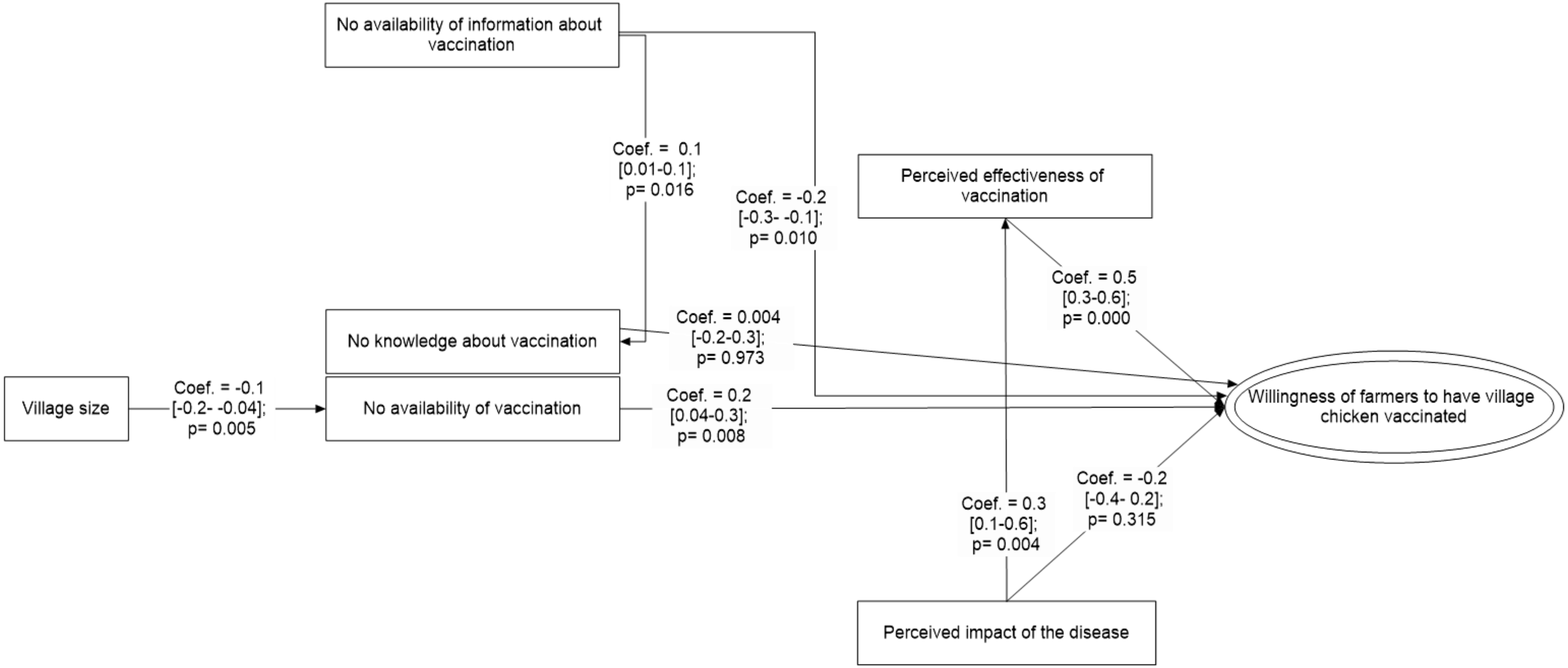


Figure 6.7 Causal path modelling approach to understand farmers' perception on Newcastle disease (ND) vaccination practice in village chicken production indicating Coef: path coefficient with confidence limit; p: p-value

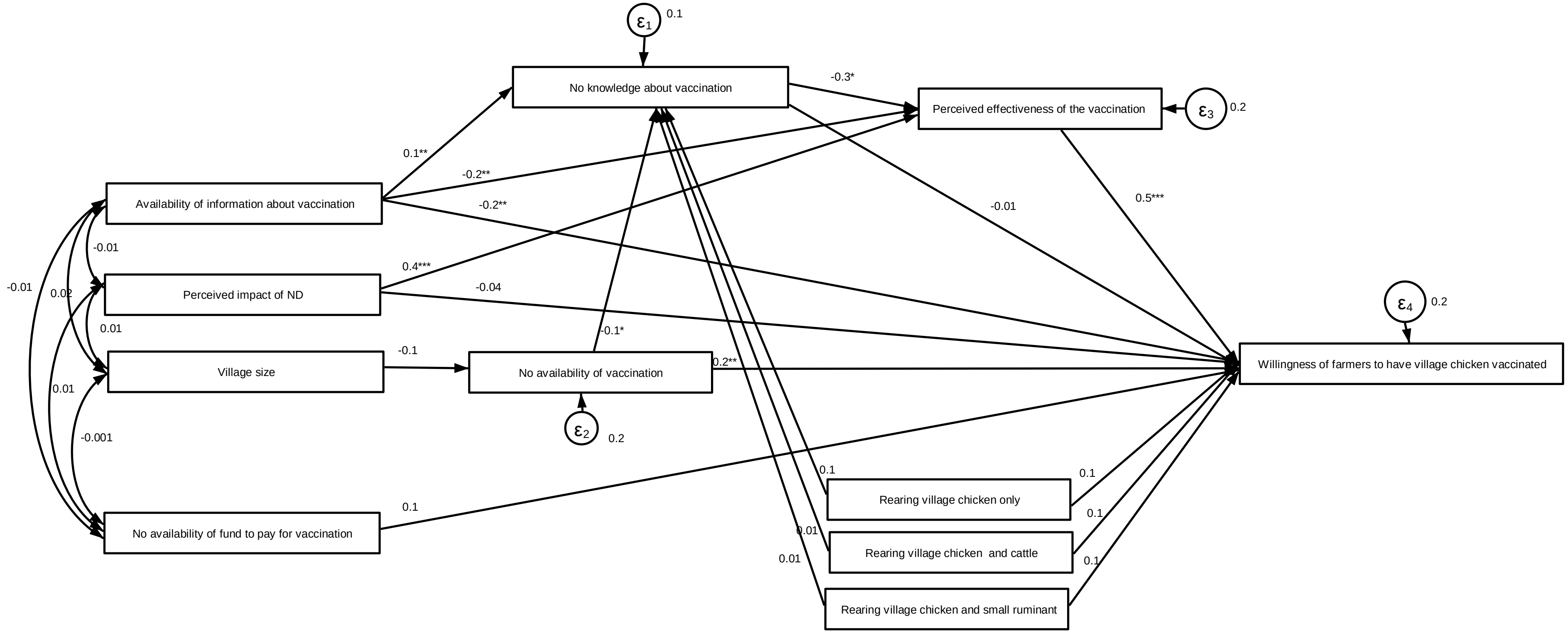


Figure 6.8 The complete path model analysis to understand the factors affecting the willingness of farmers to have village chickensvaccinated

6.5.2.5 Indirect effects

The final path models revealed similarities of direct effects for the three livestock ownership groups, but also similar indirect effects impacting on the willingness of farmers to vaccinate their animals. For example, perceived impact of the disease based on the economic losses associated with diseases (i.e. FMD and ND) (indirect effect: $\beta = 0.05$, SE= 0.02, $p = 0.032$ in cattle; $\beta = 0.09$, SE= 0.06, $p = 0.023$ in village chickens), but also unavailability of vaccinations (indirect effect: $\beta = -0.05$, SE= 0.03, $p = 0.063$ in cattle; $\beta = -0.02$, SE= 0.02, $p = 0.247$ in small ruminants; $\beta = -0.06$, SE= 0.07, $p = 0.056$ in village chickens) indirectly impacted on the willingness of farmers to vaccinate. Across all three livestock species, village size indirectly affected the willingness to vaccinate (Indirect effect: $\beta = -0.01$, SE= 0.01, $p = 0.450$ in cattle; $\beta = -0.01$, SE= 0.00, $p = 0.208$ in small ruminants; $\beta = -0.02$, SE = 0.01, $p = 0.054$ in village chickens) (Tables 6.6-6.8).

Table 6.6 Path analysis modelling approach to understand the perception of cattle farmers on FMD vaccination practice *(p-value: * = <0.05; ** = <0.01; *** = <0.001)*

Variables	Std. coefficient	SE	p-value
Indirect effect			
Perceived effectiveness of the vaccination <-			
No availability of information about vaccination	-0.04	0.02	0.028
Information provided through local authorities	-0.01	0.01	0.133
Previous occurrence of clinical FMD on farms	0.00	0.01	0.979
Willingness of farmers to have cattle vaccinated <-			
No knowledge about vaccination	-0.05	0.03	0.063
Total income per year in USD	0.00	0.00	0.667
Perceived impact of the disease	0.05	0.02	0.032
No availability of information about vaccination	-0.09	0.03	0.005
Information provided through local authorities	-0.03	0.01	0.068
Village size	-0.01	0.01	0.450
Main income source: Livestock sale	0.00	0.00	0.628
Previous occurrence of clinical FMD on farms	0.00	0.00	0.979
Rearing cattle only	0.00	0.00	0.658
Rearing cattle and small ruminants	0.00	0.00	0.634
Rearing cattle and village chickens	0.00	0.00	0.648
No availability of funds to pay for vaccination <-			
Village size	-0.01	0.01	0.168
Main income source: Livestock sale	0.01	0.01	0.380
Rearing cattle only	-0.02	0.01	0.249
Rearing cattle and small ruminants	-0.01	0.01	0.416
Rearing cattle and village chickens	-0.01	0.01	0.278
Total effects			
No knowledge about vaccination <-			
No availability of information about vaccination	0.25	0.05	0.002
Information provided through local authorities	0.09	0.02	0.039
No availability of vaccination <-			
Village size	-0.20	0.04	0.001
Total income per year in USD <-			
Village size	0.12	0.06	0.031
Main income source: Livestock sale	-0.07	0.10	0.374
Rearing cattle only	0.13	0.08	0.091
Rearing cattle and small ruminants	0.08	0.12	0.387
Rearing cattle and village chicken	0.11	0.09	0.188
Perceived effectiveness of the vaccination <-			
No knowledge about vaccination	-0.16	0.08	0.009
Perceived impact of the disease	0.17	0.07	0.034
No availability of information about vaccination	-0.04	0.02	0.028
Information provided through local authorities	-0.01	0.01	0.133
Previous occurrence of clinical FMD on farms	0.00	0.01	0.979
Willingness of farmers to have cattle vaccinated <-			
No knowledge about vaccination	-0.38	0.10	0.000
No availability of vaccination	0.05	0.05	0.416

Variables	Std. coefficient	SE	p-value
Total income per year in USD	0.00	0.00	0.667
Perceived effectiveness of the vaccination	0.30	0.11	0.018
No availability of funds to pay for vaccination	0.02	0.04	0.645
Perceived impact of the disease	0.10	0.07	0.239
No availability of information about vaccination	-0.09	0.03	0.005
Information provided through local authorities	-0.03	0.01	0.068
Village size	-0.01	0.01	0.450
Main income source: Livestock sale	0.00	0.00	0.628
Previous occurrence of clinical FMD on farms	0.00	0.00	0.979
Rearing cattle only	0.08	0.05	0.216
Rearing cattle and small ruminants	0.03	0.06	0.706
Rearing cattle and village chickens	0.02	0.06	0.862
***No availability of funds to pay for vaccination* <-**			
Total income per year in USD	-0.12	0.04	0.064
Village size	-0.01	0.01	0.168
Main income source: Livestock sale	0.01	0.01	0.380
Rearing cattle only	-0.02	0.01	0.249
Rearing cattle and small ruminants	-0.01	0.01	0.416
Rearing cattle and village chickens	-0.01	0.01	0.278
***Perceived impact of the disease* <-**			
Previous occurrence of clinical FMD on farms	0.00	0.06	0.979

Table 6.7 Path analysis modelling approach to understand the perception of small ruminant farmers on FMD vaccination practice

Variables	Std. coefficient	SE	p-value
Indirect effect			
No availability of information about vaccination <-			
Total income per year in USD	0.01	0.01	0.377
Rearing small ruminants and village chickens	0.00	0.00	0.420
Village size	0.00	0.00	0.381
Main income source: Livestock sale	0.00	0.00	0.903
Rearing small ruminants only	-0.01	0.01	0.335
Rearing small ruminants and cattle	0.00	0.00	0.539
Willingness of farmers to have small ruminants vaccinated <-			
No availability of information about vaccination	0.00	0.00	0.737
Total income per year in USD	0.00	0.00	0.459
No knowledge about vaccination	-0.02	0.02	0.247
No availability of funds to pay for vaccination	0.03	0.02	0.150
Age	0.02	0.01	0.345
Gender	-0.01	0.01	0.357
Rearing small ruminants and village chickens	0.00	0.00	0.477
Village size	-0.01	0.00	0.208
Main come source: Livestock sale	0.00	0.00	0.904
Previous occurrence of clinical FMD on farms	-0.01	0.02	0.503
Rearing small ruminants only	0.00	0.01	0.856
Rearing small ruminants and cattle	-0.01	0.01	0.392
No knowledge about vaccination <-			
Total income per year in USD	0.00	0.00	0.729
No availability of funds to pay for vaccination	0.00	0.01	0.728
Age	0.00	0.01	0.750
Gender	0.00	0.00	0.738
Rearing small ruminants and village chickens	0.00	0.00	0.741
Village size	0.00	0.00	0.729
Main income source: Livestock sale	0.00	0.00	0.906
Rearing small ruminants only	0.00	0.00	0.730
Rearing small ruminants and cattle	0.00	0.00	0.767
Perceived effectiveness of the vaccination <-			
No availability of information about vaccination	0.00	0.01	0.729
Total income per year in USD	0.00	0.00	0.743
No availability of funds to pay for vaccination	0.00	0.00	0.733
Age	0.00	0.00	0.755
Gender	0.00	0.00	0.745
Rearing small ruminants and village chickens	0.00	0.00	0.754
Village size	0.00	0.00	0.741
Main income source: Livestock sale	0.00	0.00	0.906
Rearing small ruminants only	-0.01	0.01	0.421
Rearing small ruminants and cattle	-0.02	0.01	0.207
No availability of funds to pay for vaccination <-			
Rearing small ruminants and village chickens	-0.01	0.01	0.399
Village size	-0.01	0.01	0.373

Variables	Std. coefficient	SE	p-value
Main income source: Livestock sale	0.00	0.00	0.905
Rearing small ruminants only	0.00	0.00	0.611
Rearing small ruminants and cattle	-0.01	0.01	0.529
<u>Total effects</u>			
***No availability of information about vaccination* <-**			
Total income per year in USD	0.01	0.01	0.377
No availability of funds to pay for vaccination	-0.14	0.09	0.039
Age	-0.09	0.08	0.286
Gender	0.07	0.06	0.326
Rearing small ruminants and village chickens	0.00	0.00	0.420
Village size	0.00	0.00	0.381
Main income source: Livestock sale	0.00	0.00	0.903
Rearing small ruminants only	-0.01	0.01	0.335
Rearing small ruminants and cattle	0.00	0.00	0.539
***Total income per year in USD* <-**			
Rearing small ruminants and village chickens	0.21	0.11	0.018
Village size	0.17	0.07	0.020
Main income source: Livestock sale	0.01	0.09	0.904
Rearing small ruminants only	-0.05	0.10	0.578
Rearing small ruminants and cattle	0.08	0.12	0.419
***Willingness of farmers to have small ruminants vaccinated* <-**			
Availability of information about vaccination	-0.20	0.06	0.014
Total income per year in USD	0.00	0.00	0.459
No knowledge about vaccination	-0.08	0.07	0.351
No availability of vaccination	0.05	0.08	0.155
Perceived effectiveness of the vaccination	0.21	0.12	0.089
No availability of funds to pay for vaccination	0.06	0.05	0.178
Perceived impact of the disease	0.22	0.07	0.005
Age	0.02	0.01	0.345
Gender	-0.01	0.01	0.357
Rearing small ruminants and village chickens	0.10	0.06	0.142
Village size	-0.17	0.05	0.018
Main income source: Livestock sale	0.00	0.00	0.904
Previous occurrence of clinical FMD on farms	-0.01	0.02	0.503
Rearing small ruminants only	-0.03	0.08	0.757
Rearing small ruminants and cattle	0.03	0.07	0.668
***No knowledge about vaccination* <-**			
No availability of information about vaccination	-0.02	0.06	0.722
Total income per year in USD	0.00	0.00	0.729
No availability of funds to pay for vaccination	0.00	0.01	0.728
Age	0.00	0.01	0.750
Gender	0.00	0.00	0.738
Rearing small ruminants and village chickens	0.00	0.00	0.741
Village size	0.00	0.00	0.729
Main income source: Livestock sale	0.00	0.00	0.906
Rearing small ruminants only	0.09	0.07	0.288
Rearing small ruminants and cattle	0.17	0.09	0.058

Variables	Std. coefficient	SE	p-value
No availability of vaccination **<-**			
Village size	-0.15	0.02	0.027
Perceived effectiveness of the vaccination **<-**			
No availability of information about vaccination	0.00	0.01	0.729
Total income per year in USD	0.00	0.00	0.743
No knowledge about vaccination	-0.11	0.08	0.172
No availability of funds to pay for vaccination	0.00	0.00	0.733
Age	0.00	0.00	0.755
Gender	0.00	0.00	0.745
Rearing small ruminants and village chickens	0.00	0.00	0.754
Village size	0.00	0.00	0.741
Main income source: Livestock sale	0.00	0.00	0.906
Rearing small ruminants only	-0.01	0.01	0.421
Rearing small ruminants and cattle	-0.02	0.01	0.207
No availability of funds to pay for vaccination **<-**			
Total income per year in USD	-0.07	0.05	0.365
Rearing small ruminants and village chickens	-0.01	0.01	0.399
Village size	-0.01	0.01	0.373
Main income source: Livestock sale	0.00	0.00	0.905
Rearing small ruminants only	0.08	0.05	0.317
Rearing small ruminants and cattle	-0.01	0.01	0.529
Perceived impact of the disease **<-**			
Previous occurrence of clinical FMD on farms	-0.07	0.07	0.457

Table 6.8 Path analysis modelling approach to understand the perception of village chicken farmers on ND vaccination practice

Variable	Std. coefficient	SE	p-value
Indirect effect			
Willingness of farmers to have village chickens vaccinated <-			
No knowledge about vaccination	-0.06	0.07	0.056
No availability of information about vaccination	-0.10	0.06	0.122
Village size	-0.02	0.01	0.054
Perceived impact of the disease	0.09	0.06	0.023
Rearing village chickens only	0.00	0.01	0.969
Rearing village chickens and cattle	0.01	0.01	0.655
Rearing village chickens and small ruminants	0.00	0.01	0.716
Perceived effectiveness of the vaccination <-			
No availability of information about vaccination	-0.02	0.01	0.138
Rearing village chickens only	0.00	0.02	0.970
Rearing village chickens and cattle	0.01	0.02	0.536
Rearing village chickens and small ruminants	0.01	0.02	0.647
Total effects			
Willingness of farmers to have village chickens vaccinated <-			
No knowledge about vaccination	-0.06	0.14	0.379
Perceived effectiveness of the vaccination	0.44	0.08	0.000
No availability of vaccination	0.12	0.06	0.008
No availability of funds to pay for vaccination	0.07	0.11	0.278
No availability of information about vaccination	-0.29	0.05	0.000
Village size	-0.02	0.01	0.054
Perceived impact of the disease	0.00	0.16	0.983
Rearing village chickens only	-0.04	0.07	0.585
Rearing village chickens and cattle	0.04	0.07	0.610
Rearing village chickens and small ruminants	0.14	0.08	0.056
No knowledge about vaccination <-			
Availability of information about vaccination	0.15	0.03	0.016
Rearing village chickens only	0.00	0.06	0.97
Rearing village chickens and cattle	-0.09	0.05	0.456
Rearing village chickens and small ruminants	-0.06	0.06	0.593
Perceived effectiveness of the vaccination <-			
Barrier: Knowledge about vaccination	-0.14	0.15	0.061
Availability of information about vaccination	-0.22	0.10	0.050
Perceived impact of the disease	0.21	0.11	0.004
Rearing village chickens only	0.00	0.02	0.970
Rearing village chickens and cattle	0.01	0.02	0.536
Rearing village chickens and small ruminants	0.01	0.02	0.647
No availability of vaccination <-			
Village size	-0.19	0.05	0.005

6.6 Discussion

In this study, I explored the effects of the perception of livestock farmers on their willingness to conduct FMD vaccinations in cattle and small ruminants and ND vaccination in village chickens. This study is novel in a number of ways. Firstly, data collected focused on the comparison of livestock disease prevention practices in multispecies owning households. Secondly, it used the health belief framework to explore factors impacting on willingness to conduct vaccinations while comparing cattle, small ruminant and village chicken households. This is the first study in Myanmar that explores the relationship between human perceptions and livestock disease prevention methods.

Willingness of farmers to vaccinate their livestock differed between the three major livestock species, with cattle and small ruminant farmers being more willing to vaccinate than village chicken farmers, probably due the different value of livestock species to the household income. Interestingly, keeping combinations of different livestock species, a common feature in small-scale multispecies households in Myanmar, did not impact on the willingness of farmers to vaccinate. For cattle and village chicken owners the perceived impact of FMD and ND, in particular reduced weight gain, reduced production and mortalities (Mathew and Menon 2008, Paarlberg and Lee 1998) and perhaps experiences with previous vaccinations, influenced their trust in the effectiveness of FMD and ND vaccines and thereby increased their willingness to vaccinate. For small ruminant farmers, the perceived economic impact of FMD directly influenced the willingness to vaccinate, probably as the sale of animals is the main reason for raising small ruminants (JICA 2010) and therefore farmers are very concerned about the impact of FMD on their livestock sales (Hinson 2015, Stevens 1958).

Limited availability of information about livestock diseases and their prevention and unavailability of vaccination campaigns were identified as major barriers. However, the availability of information and the vaccine differed between the three livestock species groups, which is a reflection of the limitations of animal health and veterinary services (Mazumder, Kalita et al. 2014, McDermott, Staal et al. 2010) and information campaigns to equally cover all livestock species (Henning, Pym et al. 2007, Maass, Katunga Musale et al. 2012, Mazumder, Kalita et al. 2014, McDermott, Staal et al. 2010). Surprisingly, about 17.5% of cattle and 15.4% of village chicken owners, but only 2.3% of small ruminant owners indicated non-availability of vaccination affected their willingness to vaccinate. The reason for this might be that small ruminant farmers might actually not be aware of the existence of an FMD vaccine – this is also supported by the observation that twice as many small ruminant farmers compared to cattle and village chicken farmers had no knowledge about vaccinations and no funds to conduct vaccinations.

It has been highlighted previously that promoting awareness about infectious livestock diseases will increase vaccination rates (Mazumder, Kalita et al. 2014, McDermott, Staal et al. 2010). However, it is essential to use appropriate extension messages and approaches to advise farmers on methods to improve livestock health (Henning, Hla et al. 2014). Our study identified that accessibility to information and to vaccinations was determined by village size. Thus, vaccinations and information campaigns were not uniformly conducted in all rural areas and most likely campaigns focused on easily assessable locations or more densely populated areas (which often have a better infrastructure such as roads and therefore can be more easily reached). However, trade of livestock and animal movements are the main factors supporting the spread of FMD and ND viruses between farms, villages and markets (Ortiz-Pelaez, Pfeiffer et al. 2006, Perry, Gleeson et al. 2002) and thus there should be no excuse for smaller villages to be excluded from disease prevention programmes. Supporting both large and small villages in the prevention of infectious ruminant and poultry diseases will help to improve the endemic FMD and ND situation and ultimately to improve the livelihood of farmers. On the other hand, very surprisingly, based on the observed indirect effects (although not significant at $p>0.05$), farmers in larger villages were less willing to conduct vaccinations. For example, during informal discussions with some cattle farmers, concerns about adverse effects of vaccination such as "cattle becoming dull and insipid to work in the field" or "cattle showing depression after vaccination" were raised – thus, it seems, that larger villages with better access to vaccinations might have experienced unsatisfactory vaccination effects. However, the importance of this observation is not clearly understood and further research study is recommended to investigate.

Our study had a number of limitations. Firstly, responses of farmers to questions using the health belief framework were dichotomised as farmers were unable to provide more detailed answers on a Likert-type scale. Secondly, the two diseases studied here (FMD and ND) can present themselves by a wide range of clinical symptoms and some of these symptoms might also be associated with other livestock diseases. For example, both ND and avian influenza (AI) often result in sudden mortality of birds and as in free-ranging chickens, farmers might not be able to observe additional clinical signs before the death of birds, they might also not be able to clearly distinguish between these two diseases. ND is endemic in Myanmar since many decades (Oo 2013, 2014) and farmers are well aware of the this disease, while AI is only emerged approximately 20 years ago and is probably occurring more spatially and temporally limited compared to ND. However, to overcome the limitation of a potentially misdiagnosis by farmers, we focused our analysis only on farmers who were fully aware and could clearly recognize ND, and also FMD symptoms.

6.7 Conclusions

We identified that perceptions on the effectiveness of vaccination, poor knowledge about the use of vaccination and limited availability of vaccine and vaccinators limited the willingness of farmers to conduct vaccinations, while the perceived impact of the diseases increased farmers’ willingness for preventive actions. On the other hand, indirect factors, such as village size strongly influenced the availability of vaccinations. Our study highlights that policies that increase the accessibility to vaccines and the dissemination of information about disease prevention and vaccination practices in village of all sizes, have the potential to increase FMD and ND vaccination rates and thereby reduce outbreak occurrence in Myanmar.

CHAPTER 7

PERCEPTIONS OF LIVESTOCK VALUE CHAIN ACTORS (VCAs) ON THE RISK OF ACQUIRING ZOONOTIC DISEASES FROM THEIR LIVESTOCK

7.1 Context

In the previous three chapters (Chapter 4-6), we have compared livestock husbandry and health management practices, health problems, and income across different livestock households. In those chapters we have also investigated the husbandry factors influencing herd/flock structure and health problems in the Central Dry Zone (CDZ) of Myanmar. In addition, analysis presented in Chapter 6 identified factors determining vaccination practices for major livestock diseases (FMD and ND) in the CDZ. Zoonotic infections correspond to 60% of human infections worldwide. There is a need to investigate the perceptions and practices of local people who rear and work closely with livestock, on zoonoses to suggest the development of further zoonoses control strategies. While the description of the current livestock production system and health in the CDZ of Myanmar is important to understand risk of transmission of zoonoses, we also need to understand the attitudes and prevention practices of value chain actors (VCAs) (i.e. farmers, hawkers, middlemen, branch collectors, and traders) towards zoonotic risk from their livestock.

In this Chapter, we aimed to investigate the attitudes and awareness of VCAs towards zoonoses transmission. In order to achieve that we designed a data collection instrument based on constructs of the health belief model (HBM). The HBM has been used to identify social and psychological factors affecting disease prevention practices. In this study, a modified HBM questionnaire was developed to capture information on perceived susceptibility, perceived severity, perceived barriers, cues to action, and self-efficacy of livestock VCAs for the prevention of zoonoses in the CZD of Myanmar. We adjusted the analysis on the density of animal trade as one of the determinants for the practice of zoonoses prevention. The findings from this research provided information about the limitations and constraints for VCAs' awareness of zoonoses and prevention practices. Furthermore, the results of this study help to support the identification of reliable and efficient strategies to improve knowledge of disease control and prevention through livestock marketing networks, and thereby increase the farmers' incomes and livelihoods in the CDZ.

7.2 Abstract

The Central Dry Zone (CDZ) is one of the most important livestock production areas of Myanmar. This region supports 10 million people whose livelihoods depend on small-scale, dry-land agriculture, but it is also one of the poorest regions of Myanmar. Livestock production is a major income source for farmers in the CDZ, but there is an eminent lack of information on the attitudes and traditional beliefs of local farmers and livestock traders in CDZ of Myanmar on livestock diseases and their public health implications. In this project, quantitative survey techniques were used to compile data on livestock production, livestock health and livestock trading from cattle, sheep and goat and village chicken VCAs. A modified data collection instrument of the Health Belief model was developed to investigate attitudes, beliefs and barriers to the application of recommended zoonotic disease prevention. Data analyses were conducted considering a two-phase modelling approach: in Phase 1 we aimed to identify factors associated with the perceived threat of zoonoses by VCAs and in Phase 2 we aimed to investigate factors associated with disease prevention self-efficacy. Multilevel mixed effect binomial generalized linear models were built in both phases. Our results indicate that perceived threat of zoonoses transmitted from cattle (Chi-square = 38.3, $p<0.01$) and poultry (Chi-square = 6.4, $p<0.05$) showed significant difference between farmers and traders groups. Male VCAs were 1.5 times more likely to be aware of zoonotic threats than females. People not rearing or trading small ruminants and/or poultry were less likely to be aware of zoonotic risks associated with these animals ($p<0.05$). Our results also indicated that farmers were more likely to access information on zoonotic risks than traders (Chi-square = 51, $p<0.001$ for zoonotic disease transmitted from cattle; Chi-square = 29.9, $p<0.001$ for zoonotic disease transmitted from small ruminants; Chi-squared = 28, $p<0.001$ for zoonotic disease transmitted from poultry). Information on zoonoses transmitted through small ruminants was mainly disseminated through farmers ($p<0.05$), while information on zoonotic diseases that can be obtained from poultry was disseminated through farmers, local authorities and the media. Although traders reported a number of preventive methods to reduce disease transmission in cattle, none of them seemed to conduct these preventions ($p>0.05$). Nevertheless, appropriate hand hygiene measures (i.e. cleaning of hands after touching, cutting, cooking meat) and treating of sick animals increased the confidence of small ruminant and village chicken owners to prevent zoonotic diseases ($p<0.05$). The trade connectivity did not show any significant relationship with the awareness of zoonoses threat ($p>0.05$). The findings from this study indicate that while gender and the availability of information on zoonotic risks play an important role on the perceived threat of zoonoses, the practice of prevention methods influenced the confidence of VCAs on zoonoses prevention (self-efficacy).

Keywords*:* zoonoses, health belief model, livestock farmers, traders

7.3 Introduction

Approximately 60% of all human infectious diseases originate from animals (Taylor, Latham et al. 2001b, WHO 2011, 2014). Zoonotic diseases such as anthrax, brucellosis, rabies, Japanese encephalitis, Q fever, *Trichinella spp*., tuberculosis, salmonellosis and avian influenza are a significant threat to global population health by affecting general population health, food security and economic and social development (OIE 2016).

Zoonotic infection has been threatening the world population with wide spread geographical distribution. Due to its negative impact, zoonoses remain a public health challenge in resource poor regions of Southeast Asia (Cáceres 2009). The population of Myanmar has experienced a number of zoonotic disease outbreaks including anthrax (Kunanusont, Limpakarnjanarat et al. 1990, Narayan, Sreelakshmi et al. 2009, Samad and Hoque 1986), brucellosis (Oo 2013, 2014), highly pathogenic avian influenza (HPAI) and avian salmonellosis (Oo 2013, 2014). As in many developing nations with limited veterinary services and poor health management, zoonotic parasitic infections are also common (Irwin and Jefferies 2004, McLeod 2004) including ascariasis, coccidiosis, fascioliasis, oesophagostomiasis, strongyloid nematode infection which have been reported for both large and small ruminants (McLeod 2004, Oo 2013, 2014). These reports also reflect the threat of zoonoses to people, especially farmers and livestock traders who work closely with animals. However, information on the perceptions of VCAs in the CDZ regarding zoonotic risks from their livestock is still scarce.

A number of factors trigger the introduction and spread of zoonoses including social and traditional behaviours (e.g. food habit, lack of adequate health care, and farming practice, living close to animals), demographic factors (e.g. sex, age, experience), environmental factors (e.g. global climate changes), pathogenic factors (e.g. genetic changes in pathogens) (Binder, Levitt et al. 1999, Desselberger 2000, Ebel and Spielman 1998, Lederberg, Shope et al. 1992, Stein 2003, Wilson 1995) and management factors (e.g. poor sanitary regulations, poor health management and inadequate veterinary services) are all related to favourable conditions for the transmission of zoonoses (Bellaver and Bellaver 1999, Chawatama, Mutisi et al. 2005, Komba, Komba et al. 2012, Maass, Katunga Musale et al. 2012, Thomas, Zerbini et al. 2002). Also a lack of knowledge on disease prevention methods, biosecurity measures and zoonotic diseases is a main concern in developing countries (Cáceres 2009, Conan, Goutard et al. 2012) affecting the awareness of zoonotic threats and practice of disease prevention methods and thereby promoting the self-efficacy of stakeholders on zoonotic disease prevention (i.e. ability to prevent the zoonotic diseases being transmitted from livestock species to humans). In addition, animal movement has been notorious for being a critical issue in zoonotic disease transmission (Balkhy and Memish 2003, Fèvre, Bronsvoort et al. 2006) and public health implications. This also leads to promote our interest in the role of different levels of stakeholders in the threat of zoonoses and prevention practice. The communication and knowledge sharing among different levels of stakeholders in trade routes might promote the accessibility to zoonoses information and this might compound awareness of zoonoses threats.

To improve the control of zoonoses by different VCAs in the CDZ, we need to understand the limitations and opportunities for improving the attitude and practice of the farmers relating to the threat of zoonoses. The Health Belief model was firstly introduced to the health educational research in the 1950s by social psychologists Hochbaum, Rosenstock, and Kegels, who worked with the U.S. Public Health Service (Becker 1974, Maiman and Becker 1974) to look at the relationship between human cognitive behaviour, and practice of health preventive measures. It has been widely used among health psychology researchers. The Health Belief framework has been successfully used in determination of the psychological influence on taking preventive action in many human health researches (D'Souza, Zyngier et al. 2011, Dodel and Mesch 2017, Montanaro and Bryan 2014). However, the use of the Health Belief framework for disease prevention practice has not been widely seen in veterinary medicine.

In this study we aimed to improve our understanding of attitudes and beliefs of local farmers and traders on zoonoses in the CDZ. This will help to support the development of strategies to overcome constraints on zoonoses control and promoting the health status of VCAs in the CDZ of Myanmar under the one-health paradigm.

7.4 Material and Methods

7.4.1 Study design

A cross-sectional questionnaire survey was conducted among small-scale farming households owning different livestock species in two administrative areas (townships), Myingyan and Meikhtila, in the CDZ of Myanmar. These two CDZ townships were key research sites for a larger livestock project (DAHAT PAN project), funded by the Australian Centre for International Agriculture Research (ACIAR), and been previously identified as representative of livestock production systems and practices performed throughout the wider CDZ (ACIAR 2013).

7.4.2 Selection of sampling units for farmer household data

For the selection of farmers, a two-stage sampling approach was used to identify villages and households in the survey, with primary sampling units (PSU) being villages and secondary sampling units (SSU) being households. Sample size calculation was done by using Epi Tools (Sergeant 2014b). According to the results of sample size calculations, we collected data from seven households in each livestock ownership group (cattle, small ruminants and village chickens), making 21 households in each of 40 villages in the CDZ (see Chapter 3).

7.4.3 Selection of sampling units for trader data

Data were collected from the different stakeholder groups involved in the livestock marketing network (i.e. farmers, hawkers, middlemen, branch collectors, and traders (*See Chapter 3 for the definition of these terms)*) to describe the cross-species marketing network originating from small-scale livestock households in villages of the CDZ of Myanmar. Data collection were conducted over 1-2 days in each market location. Data were collected from all the main livestock traders (especially for small ruminants and village chickens) whereas convenient sampling was undertaken with other value chain actors (i.e. hawkers, middlemen, branch collector) in that locality. Interviews were conducted with a total of 31 middlemen, 19 traders, 11 hawkers, 1 cattle market managers, and 1 slaughterman. In data analyses, all levels of people mainly involved in trading including traders, middlemen, branch collectors, hawkers, and slaughtermen were categorised into one group, named “traders”. In this study, we named all the levels of stakeholders including both “farmers” and “traders” as “Value Chain Actors (VCAs)”.

7.4.4 Questionnaire survey

Questionnaires were developed in the English language. The questionnaire contained the following sections: demographic information, and perceptions on the impact of animal production on human health, and public health implications. The questions in the questionnaire were constructed by means of Health Belief modelling framework (Figure 7.1).

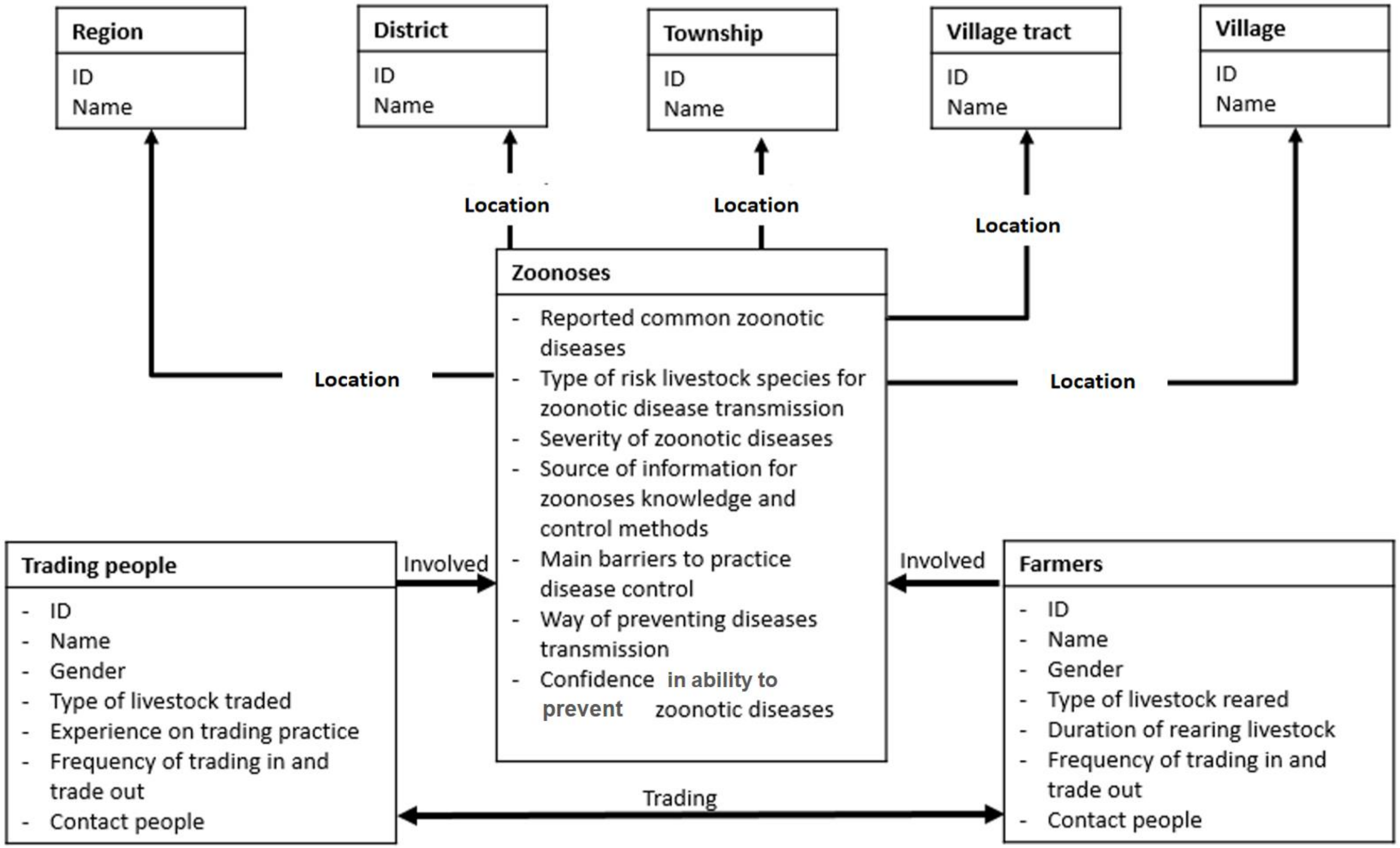


Figure 7.1 Data collection to understand the factors affecting the zoonoses control by VCAs

According to the framework, data were collected on demographic information, livestock trade information, perception of farmers on risk of zoonoses from livestock species, the availability of information on risk of zoonoses, preventive actions, main barriers to disease prevention, and the level of confidence on zoonoses control (Figure 7.1). Pilot testing of the questionnaire was conducted in three households within two villages in Meikhtila Township. The selection of these villages was conducted by analysing the score on wealth and development (1 = very poor, 2 = poor, 3 = moderate, 4 = good, 5 = very good). Scoring of the villages in Meikhtila Township was conducted by seven members of the local authority, three animal health workers and two junior scientists. Based on this ranking, one village with the highest score and one village with lowest score were chosen. In each village, three households with cattle production, sheep or goat production, and village chicken production, were surveyed. From the trading survey, the pilot test was conducted with three local traders in Bago region. After the pilot testing, a total number of six questions were modified. Questions on attitude, and practices to prevent transmissible zoonoses from livestock were adjusted and modified to be more relevant to the local conditions and improved to ensure that farmers better understood the questions asked.

After the questionnaire was finalized, a survey team was organized by seven enumerators. Enumerators were two students from the University of Yezin, four staff from LBVD and the author of this paper. Team members were trained in interviewing techniques and they familiarized themselves with the questionnaire before the survey commenced. Questionnaire interview was conducted with both trader groups and farmer groups. The duration of each interview was approximately 20 minutes.

7.4.5 Statistical analyses

7.4.5.1 Conceptual framework for the analysis

We adapted the HBM to collected information on the health-belief components, such as perceived threat, perceived severity, perceived benefit, perceived barrier, cue to action and self-efficacy of farmers and traders towards the control of zoonotic diseases (Table 7.1) (Green and Murphy 2014) .

Table 7.1 Health Belief Model on the impact of rearing different types of animals on human health

No.	Concept	Definition
1.	Perceived Threat	Humans can become infected with disease from the relevant species (cattle, small ruminants or poultry).
2.	Perceived Severity	The consequences of getting the disease from the relevant species (cattle, small ruminants or poultry) are significant enough to try to avoid for the benefit of human health.
3.	Perceived Benefits	Recommended and proper husbandry system with biosecurity system can prevent the disease transmission from the relevant species (cattle, small ruminants or poultry) to humans.
4.	Perceived Barriers	The barriers in practising proper biosecurity system and disease transmission between the relevant species (cattle, small ruminants or poultry) and humans.
5.	Cues to Action	The main action that encourages VCAs to be aware of the zoonotic diseases transmitted from the relevant species (cattle, small ruminants or poultry).
6.	Self-Efficacy	The farmers have confidence in knowing how to protect themselves from zoonotic disease from the relevant species (cattle, small ruminants or poultry).

Our analyses were conducted in two phases: firstly, to understand the factors affecting any perceived threat and secondly, to understand the factors affecting self-efficacy of farmers on zoonoses control across different livestock species. To fulfil these objectives, we developed two interlinked models, one to model perceived threats of zoonoses and another to model self-efficacy (Figure 7.2). In the first model, we assumed that awareness of potential zoonotic risk from livestock species (i.e. perceived threat) to be influenced by modifying factors (i.e. age, gender, experience in livestock rearing/trading, livestock trading density, type of career), information availability (i.e. cue to action) and awareness of VCAs on severity of transmissible zoonotic disease from livestock. Furthermore, in the second model, we assumed that self-efficacy (i.e. confidence in disease prevention) was influenced by awareness of the potential zoonotic risk from livestock species, disease prevention practices and barriers to practising disease prevention. In addition, we also assessed the influence of unidentified factors from Model 1 on self-efficacy by taking into account the residuals from the first model (Figure 7.2).

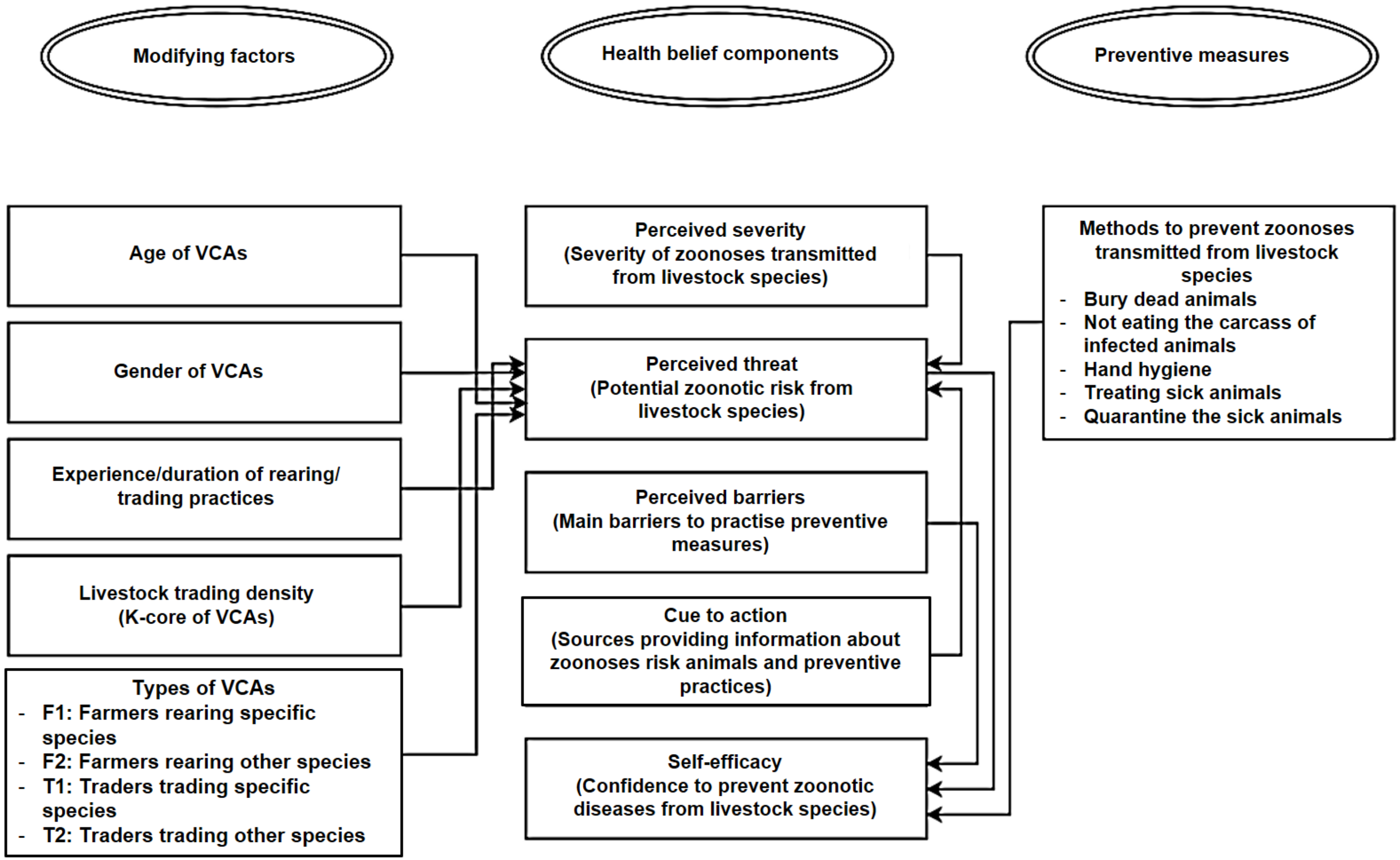


Figure 7.2 Causal diagram for health belief modelling framework on perception of zoonotic diseases by value chain actors (VCAs)

7.4.5.2 Descriptive statistical analysis

The data were analysed by cross-tabulation and descriptive analysis. Confidence intervals, standard errors, proportion and p-value were provided. Even though the outcome variables (i.e. perceived zoonoses threat and self-efficacy) were originally categorized into three: “Yes”, “No” and “Unsure”, the final outcome was categorised into only two categories which are “Yes” and “No”, with “No” being the combination of the two categories “No” and “Unsure”.

7.4.5.3 Social network analysis of livestock movements

Firstly, data on livestock trade connectivity between VCAs (i.e. farmers and traders) and locations of trade was collected from a total of 676 respondents. For the data analysis, two separated 2-mode networks each, for farmers-location network and traders-location network, were created by using social network analysis (SNA) to visualize the links and relationships (ties) between VCAs (nodes) of interest. Graph theory in SNA was used to estimate the connectivity between trading locations and each VCAs (Scott 2012). Second, to understand the livestock market chain via the VCAs in the CDZ of Myanmar, we created the 1-mode location-location network by identifying the network of trading location via VCAs.

In this study, we hypothesized that the higher connectivity in the livestock trade may contribute to information flow on zoonoses from different sources which in turn would lead to promote more awareness of VCAs on zoonoses threats. For the analysis, k-core of VCAs in livestock trading network were used as independent variables to examine the impact of connectivity on perception and awareness of VCAs on zoonoses risk and disease prevention practice. In addition, the trading locations that connected to highly connected subgroup trading locations were also identified in this study. K-core of location nodes were investigated to understand the location specific information in trading. The value of k-core in this study explained that the quantity of networks of each node in the subgroup is adjacent to the other nodes in the subgroup, thereby identifying the most influential nodes (Kitska 2010, Radicchi, Castellano et al. 2004). Furthermore, livestock trading network mapping was also developed by using social network information from geographical livestock trading network connectivity. The software Ucinet 6 and Netdraw were used in all analyses.

7.4.5.4 Modelling perceived threat of zoonoses

A multilevel mixed-effects generalized linear model was developed to identify factors associated with perceived threat of zoonoses, i.e. the knowledge of farmers on the risk and the threat of zoonoses transmitted from livestock species. Initially, we estimated the intraclass correlation coefficient (ICC) to identify whether the clustering effect of village needs to be considered for further analyses. Theoretically, ICC should be the value of >0.05 for representing the individuals within the groups resembling each other. From the results from ICC, the perceived threat of cattle, poultry and self-efficacy in prevention of disease transmitted from cattle and small ruminants was greater than 0.05. Even though the rest of the dependent variables for this study (i.e. perceived threat of small ruminants, self-efficacy on prevention of diseases transmitted through poultry) were less than 0.05, we account villages as a random affect to be constant across all models. In the mixed linear model, response variables were fixed as family 'binomial' and set 'logit' as link function. The perceived threat was set as the dependent variable and the factors such as demographic information (e.g. age, gender, experience), k-core of livestock trading (see estimation procedures below), perceived severity, cue to action and village size were set as independent variables by accounting the random effect of village in the data analysis (Figure 7.2).

7.4.5.5 Modelling self-efficacy for zoonotic disease prevention

Multilevel mixed-effects generalized linear modelling approach was conducted to identify the factors associated with the confidence in ability of VCAs to prevent zoonotic disease transmission from their animals. In the mixed linear model, response variables were fixed as family 'binomial' and set 'logit' as link function. The self-efficacy was set as dependent variables and the factors such as preventive measures, perceived barriers and residuals from first models were set as independent variables by accounting the random effect of village in the data analysis (Figure 7.2). For this second model, we used the residuals extracted from the first model (i.e. perceived threat model) as a fixed effect for association with self-efficacy for prevention of the disease. To identify the missing effect of factors not included in our model, we used the residuals extracted from the first model, which represented the factors not included in the model (Santos Nobre and da Motta Singer 2007). Using the residuals from the first model allowed us to identify whether factors not included in the first model (i.e. residual) showed significant effect on self-efficacy.

7.5 Results

7.5.1 Demographic information of VCAs

The questionnaire interview was conducted to a total of 613 farmers and 63 traders in the study areas of CDZ. Of all the respondents, the proportion of female and male was not much different in farmer groups while the proportion of gender seemed to be quite different in traders group (Chi-square = 16.8, $p<0.001$) (Table 7.2) with the median age of 46. A similar situation was also seen between farmer groups and trader groups ($p<0.05$) in duration of rearing/trading cattle, goat, village chickens and type of livestock species reared or traded (Table 7.2). More than half of the cattle and village chicken farmers had more than 5-years experience of rearing while the majority of small ruminant farmers had less than 5-years experience. The majority of the traders across all different livestock species had more than 5-yeasr experience. For the ownership groups of farmers, the proportion of farmers across all different groups was quite parallel. The majority of traders in this study practised village chicken trading (45.2% of total traders in this study) followed by cattle trading (29%), small ruminant trading (23%). Interestingly, trading small ruminants along with village chickens by a small proportion of traders (3.2%) is also noted (Table 7.2).

Table 7.2 Characteristics of livestock stakeholders (farmers and traders) in the CDZ of Myanmar
(*p< 0.05; **p<0.01; **p<0.001)

Name of variables	Categories	Farmers		Traders		X2
		N	Proportion with 95% CI	N	Proportion with 95% CI	
Gender	Male	613	49.8 (44.2-55.4)	63	76.2 (63.8-85.3)	16.8***
	Female		50.2 (44.6-55.9)		23.8 (14.7-36.2)	
Age	≤46 years old	613	48.2 (44.2-52.2)	63	71.4 (59.0-81.3)	12.3***
	>46 years old		51.8 (47.8-55.8)		28.6 (18.7-41.0)	
Experience of rearing/trading cattle	≤5 years	382	9.2 (6.4-13.2)	17	47.1 (24.9-70.4)	25.2***
	>5 years		90.8 (86.8-93.6)		52.9 (29.6-75.1)	
Experience of rearing/trading sheep	≤5 years	303	87.2 (77.9-92.9)	16	25.0 (9.4-51.9)	4.5
	>5 years		12.8 (7.1-22.1)		75.0 (48.1-90.7)	
Experience of rearing/trading goat	≤5 years	303	51.2 (43.1-59.2)	16	25.0 (9.4-51.9)	35.7***
	>5 years		48.8 (40.8-56.9)		75.0 (48.1-90.7)	
Experience of rearing/trading chicken	≤5 years	327	23.9 (17.8-31.2)	30	16.7 (7.0-34.8)	0.7
	>5 years		76.1 (68.8-82.2)		83.3 (65.2-93.0)	
Type of animal reared	Cattle only	613	21.0 (16.9-25.9)	63	29.0 (18.9-41.8)	77.0***
	Small ruminants only		15.9 (11.8-21.1)		22.6 (13.7-35.0)	
	Village chickens only		11.4 (8.1-15.9)		45.2 (33.0-57.9)	
	Cattle + Small ruminants		9.3 (6.0-14.1)		0	
	Cattle + Village chicken		17.8 (12.9-24.0)		0	
	Small ruminants + Village chickens		10.7 (7.7-14.7)		3.2 (0.8-12.4)	
	Cattle + Small ruminants + Village chickens		13.9 (9.8-19.3)		0	

7.5.2 Social network of VCAs on livestock trading

The K-core of the livestock farmers ranged from 0-2 whereas the trading connectivity of traders (K-core) was ranging from 1-3. Our result also showed that the higher K-core was seen in the livestock traders whereas the majority of farmers had K-core of ‘zero’ which means they do not belong to a highly connected subgroup. The network showing the connectivity between farmers and trading sites is highly fragmented compared to traders. It is interesting to see that the social networking link among farmers comprised of many components. The largest giant weak component (i.e. the largest component/cluster in which each nodes is connected to the component by at least one direction, which mean each VCA is connected to the location by trade-in or trade-out but not both) included 201 farmer nodes and 29 location nodes (Dubé, Ribble et al. 2011, Kao, Danon et al. 2006, O’malley and Marsden 2008, Robinson, Everett et al. 2007), the second largest components included 72 farmer nodes and 11 location nodes, and many small components (1-22 nodes in each components). However, for the trader social network connectivity, the traders seem to practise common trading location by finding only one giant weak component composed of 63 trader nodes and 220 location nodes in total from our results (Figure 7.3-7.4).

Our study highlighted that livestock trade is practised not only within townships of the study areas but also outside of the study townships (Figure 7.5). Among the total of 355 trading sites included in this study, a total of 59 trading sites (i.e. towns and villages) subgroup belonged to the highly connected subgroup (k-core = 4-5) (Table 7.3).

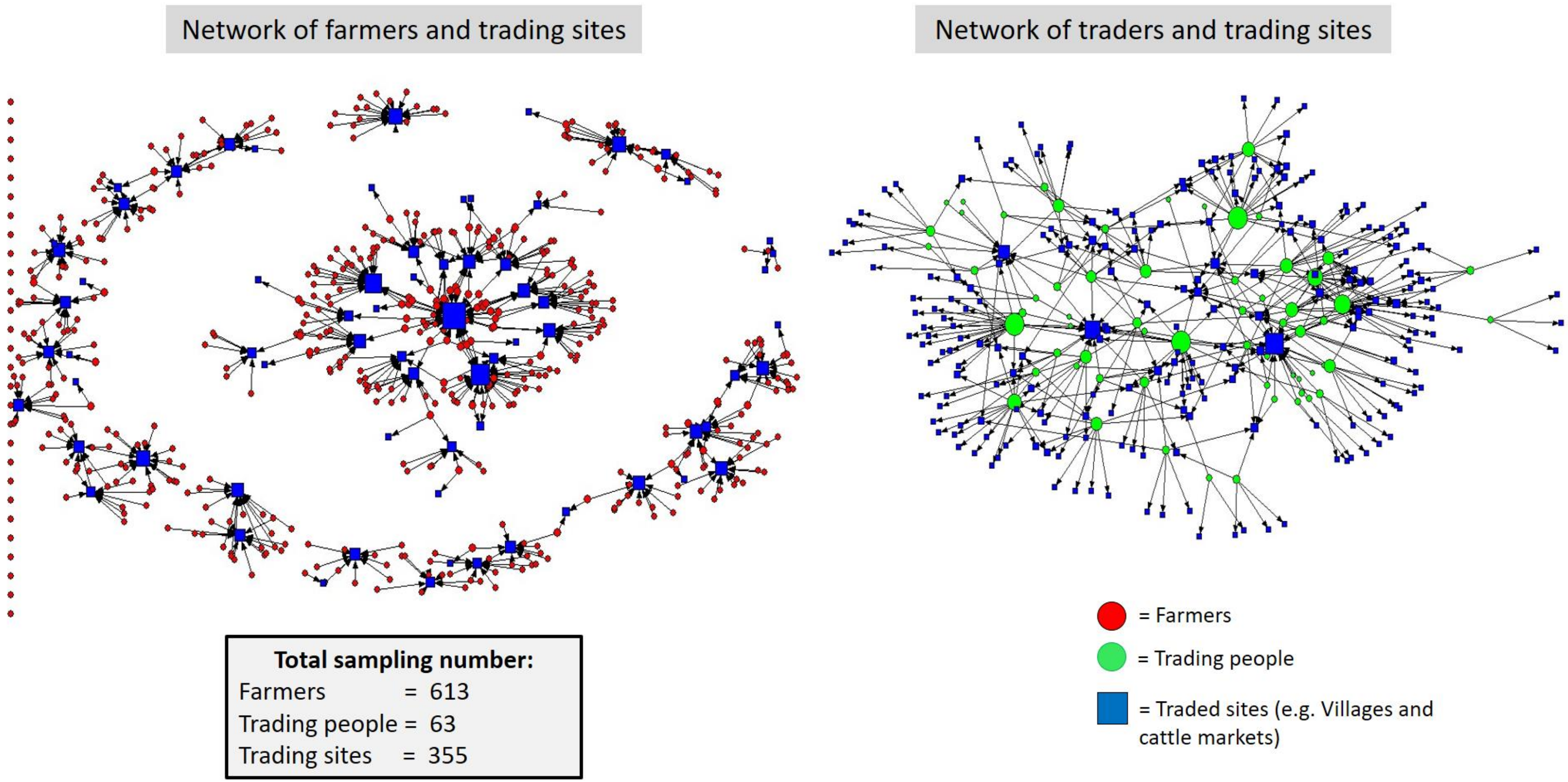


Figure 7.3 Visual social networking of livestock trading among value chain actors (i.e. farmers and traders) and the trading sites

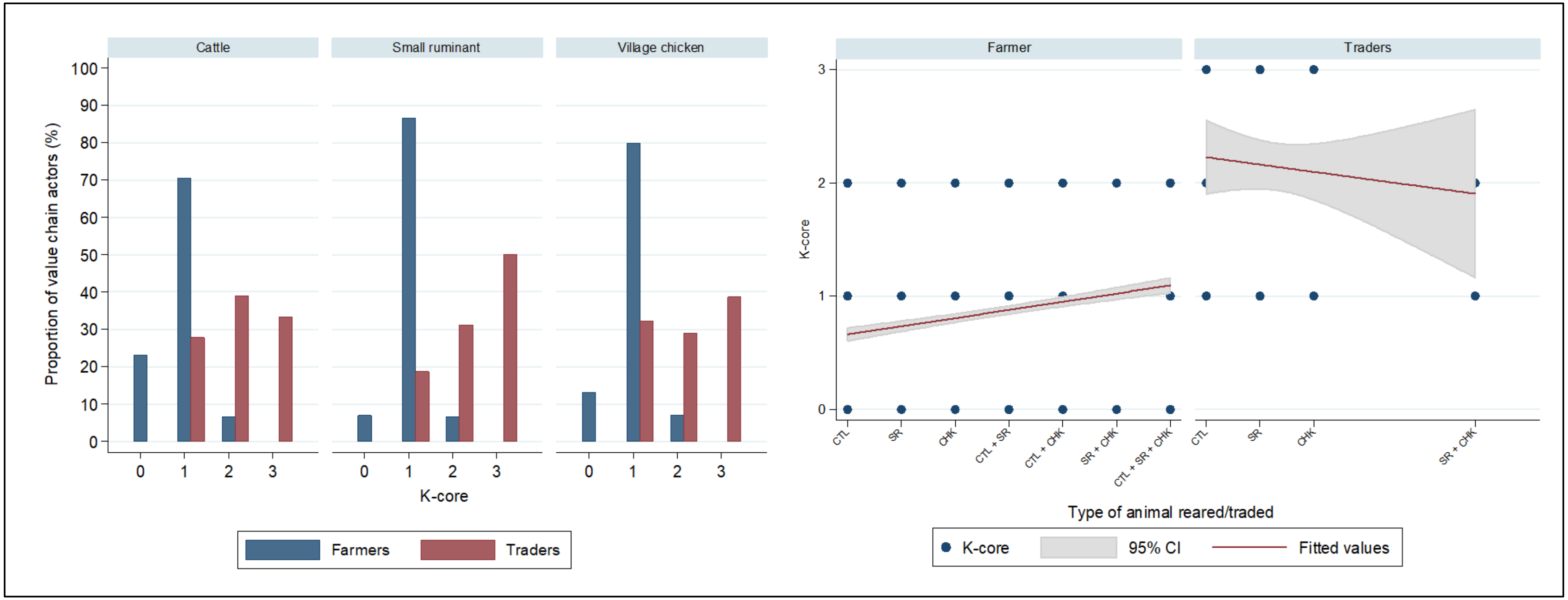


Figure 7.4 Distribution of k-core for the VCAs of livestock trading in the CDZ of Myanmar indicating CTL = cattle; SR = small ruminants; CHK = village chickens

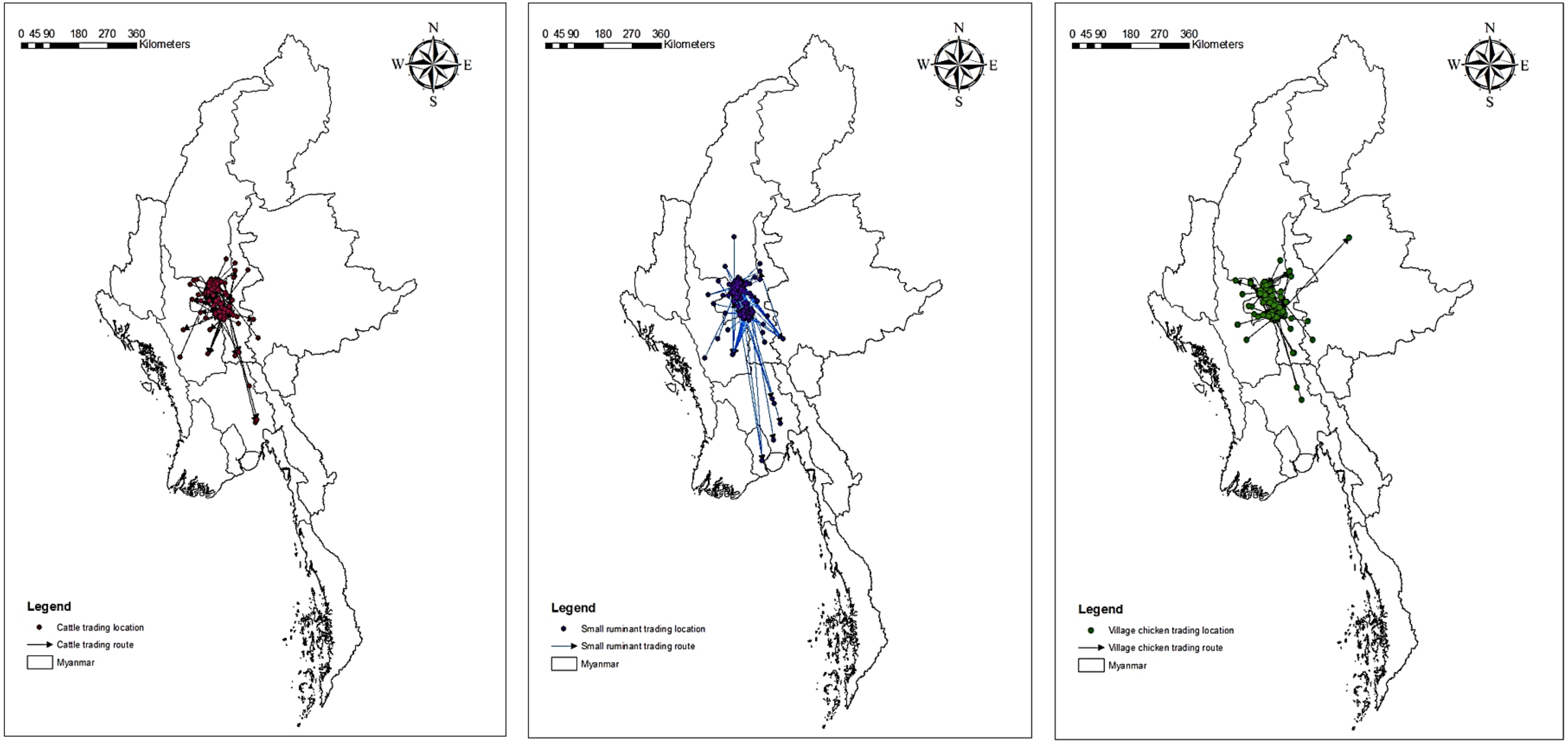


Figure 7.5 Geographical distributions of trading networks of different livestock species (cattle, small ruminants and village chickens) in the CDZ of Myanmar

Table 7.3 The list of locations (i.e. villages/towns) belonging to the highest k-core (i.e. k-core =4-5) in livestock trading network

Townships	Town/Village tract	Villages	k-core			
			Cattle trading	Small ruminant trading	Village chicken trading	All trading
Myingyan	Pyawt	Chin Myint Kyin	1	3	3	5
Myingyan	Ka Taw	Ka Taw	2	3	3	5
Meikhtila	Kan Ni	Kan Ni	1	3	3	5
Myingyan	Kyar Taing	Kyauk Kone	2	3	2	5
Mandalay	Mandalay	Cattle Market	2	2	3	5
Myingyan	Myingyan	Cattle Market	2	3	3	5
Myingyan	Nwar Ku Aing	Nwar Ku Aing	2	3	3	5
Myingyan	Hpet Pin Aing	Hpet Pin Aing	2	3	3	5
Myingyan	Yathar	Phat Yin	0	3	3	5
Myingyan	Pin Lel	Pin Lel	1	3	3	5
Myingyan	Si Mee Khon	Si Mee Khon	2	3	3	5
Myingyan	Taw Pu	Taw Pu	2	3	3	5
Myingyan	Yathar	Yathar	2	2	3	5
Meikhtila	Ah Lel	Ah Lel	2	2	1	4
Meikhtila	Shwe Sit Thi	Aung Thar	2	2	1	4
Mahlaing	Hpyauk Seik Kone	Hpyauk Seik Kone	0	3	1	4
Meikhtila	Kyaut Phoo	Hta Naung Kone	1	3	2	4
Myingyan	Hta Naung Taing	Hta Naung Taing	2	3	2	4
Meikhtila	Tha Yet Pin	Aint Kone	2	1	2	4
Meikhtila	Sat Pyar Kyin	Kan Gyi Kone	0	3	3	4
Meikhtila	Lein Taw	Kan Kaung	2	1	2	4
Meikhtila	Yae Wai	Kan Thar	1	2	3	4
Natogyi	Khat Lan	Khat Lan	1	3	2	4
Meikhtila	Thee Pin Kone	Kone Tan	2	3	1	4
Meikhtila	Gway Aing	Kwae Tauk Kan	2	3	3	4

Townships	Town/Village tract	Villages	k-core			
			Cattle trading	Small ruminant trading	Village chicken trading	All trading
Meikhtila	Kyauk Hpu	Kyauk Hpu	2	1	1	4
Meikhtila	Nyaung Pin Sho	Kyauk Pone	2	1	0	4
Meikhtila	Tha Yet Pin	Kyee Thar Aik	0	3	1	4
Meikhtila	Thee Pin Kone	Kyi Kone	2	3	3	4
Myingyan	Gyoke Pin	Gyoke Pin	2	3	3	4
Kyaukpadaung	Let Pan Pyar	Let Pan Pyar	0	0	3	4
Ma Hlaing	Ma Hlaing	Cattle Market	2	2	2	4
Meikhtila	Meikhtila	Cattle Market	2	3	3	4
Myingyan	Thar Paung	Myauk Kyone	2	3	1	4
Myingyan	Pyawt	Myin Thar	2	2	3	4
Ngazun	Myo Thar	Myo Thar	2	1	1	4
Meikhtila	Myauk Lel	Myauk Lel	1	2	3	4
Myingyan	Thin Pyun	Nyaung Pin Thar	2	3	2	4
Myingyan	Nyaung Wun	Nyaung Wun	2	1	1	4
Meikhtila	Mway	Oh Ma Twayt	2	3	2	4
Meikhtila	Ohn Ton	Ohn Ton	2	3	2	4
Ngazun	Pauk Sein	Pauk Sein	0	0	3	4
Meikhtila	Sat Pyar Kyin	Sat Pyar Kyin	2	3	3	4
Meikhtila	Shaw Hpyu Kan	Shaw Hpyu Kan	2	3	2	4
Meikhtila	Za Yat Kone	Hlyaw Hpyu Pin	2	3	3	4
Myingyan	Pyawt	Shwe Pone Thar	2	1	3	4
Kyaukpadaung	Taung U	Taung U	0	0	3	4
Meikhtila	Taw Ma	Taw Ma	2	0	0	4
Meikhtila	Sat Pyar Kyin	Tha Hpan Pin Yoe	1	2	3	4
Meikhtila	Mon Taing	Tha Yet Chan	2	3	3	4
Meikhtila	Tha Yet Pin	Tha Yet Pin	2	3	3	4

Townships	Town/Village tract	Villages	k-core			
			Cattle trading	Small ruminant trading	Village chicken trading	All trading
Meikhtila	Myauk Lel	Tha Yet Tan	2	1	2	4
Taungtha	Wea Laung	Wea Laung	1	3	2	4
Meikhtila	Taw Ma	Yae Cho	1	3	3	4
Meikhtila	Myauk Lel	Yae Ngan (West)	2	2	3	4
Meikhtila	Yae Wai	Yae Wai	2	3	3	4
Meikhtila	Yae Cho	Ywar Thar	0	3	3	4
Meikhtila	Yae Wai	Ywar Thit	1	3	2	4
Meikhtila	Za Yat Kone	Za Yat Kone	2	1	3	4

7.5.3 Perception of VCAs on zoonoses

Table 7.4 presents the results obtained from the analysis of the perceptions of the farmers and traders on risks from animal species for zoonotic disease transmission. From the data, it was seen that a greater proportion of traders thought cattle posed a moderate or high zoonotic disease risk than farmers, with the majority of the latter believing that cattle posed no zoonotic risk ($p<0.05$). In addition to this, we found a significant difference between traders and farmers in the perception of level of zoonoses severity risk across different livestock species ($p<0.001$).

The majority of VCAs (>85%) reported that they did not practise any preventive measures. However, VCAs who responded for preventive measures highlighted practising a number of preventive measures including burying the suddenly dead animals, not eating contaminated meat, treating their own sick animals and keeping their animals away from humans. Conversely, the practice of burying dead animals and quarantining the sick animal was more common for ruminants in trader groups than farmer groups ($p<0.05$). For disease transmitted from cattle, the practice of burying the dead animals was more common in farmers (18.6%, 95% CI: 5.7-21.9) than traders (4.8%, 95%CI: 1.5-14.1) (Chi-square = 7.6; $p<0.01$) and practice of keeping sick animals away from humans was more common in farmers (21.7%, 95%CI: 18.6-25.2) than traders (4.8%, 95%CI: 1.5-14.1) (Chi-square = 10.2; $p<0.01$). For prevention of transmissible diseases from small ruminants, the practice of burying the dead animal was more common in traders (4.8%, 95%CI: 1.5-14.1) than farmers (0.2%, 95%CI: 0.02-1.2) (Chi-square = 20.5; $p<0.001$).

The majority of the VCAs [farmers (82.9%, 95%CI: 79.7-85.7) and traders (98.4%, 95%CI: 89.1-99.8)] mentioned that they had no barriers to implement preventive measures. However, respondents described a number of barriers to practising disease prevention measures which included financial constraint (i.e. no funds to conduct prevention practices, not able to avoid eating infected carcass with low price due to poverty), limited knowledge (i.e. no knowledge about zoonotic diseases and how to prevent the disease being transmitted from livestock to humans) and limited resources (i.e. no separate shelter to keep livestock, limited veterinary service to treat sick animal, limited resources such as disinfection, medicine, feed containers for sanitation and poor biosecurity practices). Limited knowledge of preventive measures stood out as the most common problem across VCAs: farmers (9.0%, 95%CI: 6.9-11.5) and traders (1.6%, 95%CI: 0.2-10.9). Interestingly, it was seen that the barriers which occurred across different cattle VCAs were significantly different (Chi-square = 10.5; $p<0.05$) while there is no difference across different stakeholder groups of other livestock species (Table 7.4).

Respondents from this study reported a number of sources of information for the awareness of the risk of zoonoses and prevention measures which are the farmers, media and local authorities. 54%, 73% and 74% of cattle, small ruminant and village chicken farmers and 89% each of cattle, small ruminant and village chicken traders, respectively, reported they had obtained no information about zoonotic disease prevention from any source. On the other hand, it was noted that the main sources for public awareness of zoonoses risk were local authorities and farmers across different livestock species groups while the role of the media in public awareness was low (<5%). However, the availability of knowledge on zoonoses was different between farmers and traders indicating from the data that showed that a higher proportion of farmers reported the availability of knowledge than trader groups ($p<0.001$). In addition, our findings indicate that the source of information for zoonoses prevention was significantly different across livestock stakeholders ($p<0.001$) (Table 7.4).

Table 7.4 Health belief criteria of VCAs on the zoonotic diseases *(*p< 0.05; **p<0.01; **p<0.001,* [a] = % of a total survey population*)*

Health belief criteria	Questions	Species	Categories	Farmers (%) N = 613	Traders (%) N = 63	Χ2
Perceived threat	Which species of animal do you think can transmit zoonotic disease to human?	Cattle	Yes	16.6 (13.9-19.8)	49.2 (36.8-61.7)	38.3***
			No	83.4 (80.2-86.1)	50.8 (38.3-63.2)	
		Small ruminants	Yes	9.1 (7.1-11.7)	9.5 (4.3-19.8)	0.01
			No	90.9 (88.3-92.9)	90.5 (80.3-95.7)	
		Poultry	Yes	48.3 (44.3-52.3)	65.1 (52.3-76.0)	6.4*
			No	51.7 (47.7-55.7)	34.9 (24.0-47.8)	
Perceived severity	Which level do you consider the impacts of the risk of transmissible diseases from animal to human on human health?	Cattle	None	83.4 (80.2-86.1)	50.8 (38.3-63.2)	126.3***
			Moderate	2.1 (1.2-3.6)	34.9 (24.0-47.8)	
			High	14.5 (11.9-17.5)	14.3 (7.5-25.6)	
		Small ruminants	None	94.9 (92.9-96.4)	90.5 (80.0-95.8)	16.0***
			Moderate	0.7 (0.3-1.7)	6.3 (2.3-16.1)	
			High	4.4 (3.0-6.4)	3.2 (0.8-12.2)	
		Poultry	None	48.3 (44.3-52.3)	65.1 (52.5-75.9)	17.7***
			Moderate	9.8 (7.7-12.4)	19.1 (11.1-30.8)	
			High	41.9 (38.1-45.9)	15.9 (8.7-27.2)	
Disease prevention practice	How to prevent disease transmission from livestock to human?	Cattle	Bury dead animal[a]	18.6 (15.7-21.9)	4.8 (1.5-14.1)	7.6**
			Not eating the carcass of infected animal[a]	45.7 (41.8-49.7)	0	-
			Hand hygiene[a]	10.9 (8.7-13.7)	9.5 (4.3-19.8)	0.1
			Treating sick animal[a]	16.8 (14.0-20.0)	0	-
			Quarantine the sick animal[a]	21.7 (18.6-25.2)	4.8 (1.5-14.1)	10.2**
			Cooking the meat well[a]	0	4.8 (1.5-14.1)	-
		Small ruminants	Bury dead animal[a]	0.2 (0.02-1.2)	4.8 (1.5-14.1)	20.5***
			Not eating the carcass of infected animal[a]	3.1 (2.0-4.8)	0	-
			Hand hygiene[a]	16.8 (14.0-20.0)	9.5 (4.3-20.0)	2.2
			Treating sick animal[a]	15.7 (13.0-18.8)	0	-
			Quarantine the sick animal[a]	3.1 (2.0-4.8)	4.8 (1.5-14.1)	0.5
			Cooking the meat well[a]	0	4.8 (1.5-14.1)	-
		Poultry	Bury dead animal[a]	6.9 (5.1-9.2)	4.8 (1.5-14.1)	0.4
			Not eating the carcass of infected animal[a]	7.0 (5.2-9.3)	0	-
			Hand hygiene[a]	15.2 (12.5-18.2)	9.5 (4.3-20.0)	1.5

Health belief criteria	Questions	Species	Categories	Farmers (%) N = 613	Traders (%) N = 63	Χ2
			Treating sick animal[a]	7.8 (5.9-10.3)	0	-
			Quarantine the sick animal[a]	3.1 (2.0-4.8)	4.8 (1.5-14.1)	0.5
			Cooking the meat well[a]	0	4.8 (1.5-14.1)	
Perceived barrier	What are the barriers for preventive measures?	Cattle	No barrier	82.9 (79.7-85.7)	98.4 (89.1-99.8)	10.5*
			Financial constraint	2.8 (1.7-4.4)	0	
			Limited knowledge	9.0 (6.9-11.5)	1.6 (0.2-10.9)	
			Limited resource	5.4 (3.9-7.5)	0	
		Small ruminants	No barrier	89.6 (86.9-91.7)	98.4 (89.1-99.8)	5.4
			Financial constraint	2.1 (1.2-3.6)	0	
			Limited knowledge	4.6 (3.2-6.5)	1.6 (0.2-10.9)	
			Limited resource	3.8 (2.5-5.6)	0	
		Poultry	No barrier	89.1 (86.3-91.3)	98.4 (89.1-99.8)	5.6
			Financial constraint	2.0 (1.1-3.4)	0	
			Limited knowledge	6.5 (4.8-8.8)	1.6 (0.2-10.9)	
			Limited resource	2.5 (1.5-4.0)	0	
Cue to action	How do you obtain the information to prevent disease transmission from animal to human?	Cattle	No information obtained	54.2 (50.2-58.1)	88.9 (78.1-94.7)	51.0***
			Other farmers	21.0 (18.0-24.5)	3.2 (0.8-12.2)	
			Media	3.1 (2.0-4.8)	0	
			Local authorities	21.7 (18.6-25.2)	4.8 (1.5-14.1)	
			Other traders	0	3.2 (0.8-12.2)	
		Small ruminants	No information obtained	72.9 (69.3-76.3)	88.9 (78.1-94.7)	29.9***
			Other farmers	13.5 (11.1-16.5)	3.2 (0.8-12.2)	
			Media	1.8 (1.0-3.2)	0	
			Local authorities	4.8 (1.5-13.9)	4.8 (1.5-14.1)	
			Other traders	0	3.2 (0.8-12.2)	
		Poultry	No information obtained	74.2 (70.6-77.5)	88.9 (78.1-94.7)	28.0***
			Other farmers	10.1 (8.0-12.8)	3.2 (0.8-12.2)	
			Media	2.9 (1.9-4.6)	0	
			Local authorities	12.7 (10.3-15.6)	4.8 (1.5-14.1)	
			Other traders	0	3.2 (0.8-12.2)	
Self-efficacy	Do you think you can prevent the disease being transmitted from animal to human?	Cattle	Yes[q]	53.3 (49.4-57.3)	55.2 (41.9-67.7)	1.2
		Small ruminants	Yes[q]	37.7 (33.9-41.6)	55.2 (41.9-67.7)	1.7
		Poultry	Yes[q]	41.1 (37.3-45.1)	55.2 (41.9-67.7)	0.6

7.5.4 Factors affecting the perceived threat on zoonoses by livestock VCAs

In our first model we examined factors including demographic information, perceived severity, cue to action, associated with the perceived zoonoses threat transmitted from three livestock species (i.e. cattle, small ruminants and poultry) (Table 7.5). After initial descriptive analysis the variable Perceived Severity was excluded from further analysis due to the fact that there was no variation in responses between VCAs. Perceived threat differed between the gender of VCAs, with males 1.5 times more likely to be aware of the threat of zoonoses transmitted from cattle and poultry than females ($p<0.05$). Furthermore, the type of VCAs was also associated with the perceived threat of zoonoses by different livestock species. More traders than farmers were aware of zoonoses transmitted by cattle ($p<0.05$) while farmers not working with small ruminants and poultry were less likely to be aware of the risk of zoonoses from these animals than farmers working with these livestock species. Our results also indicate that the availability of information on zoonoses was associated with perceived threat of zoonoses. Farmers were the major source that promoted the awareness of VCAs on zoonoses transmitted from small ruminants (OR = 2.2, $p<0.05$). However, the awareness of VCAs on zoonoses transmitted from poultry was promoted by three different sources of information (i.e. media: OR = 5.4, $p<0.01$; other farmers: OR = 2.0, $p<0.05$; local authorities: OR = 2.5, $p<0.01$) (Table 7.5).

Table 7.5 Final multilevel mixed effect generalized binomial linear modelling with a random effect of location (villages) to understand the factors affecting perceived threat of VCAs on zoonotic diseases transmission

*p<0.05; **p<0.01; ***p<0.001

Variables		Perceived threat of risk animal (Odds ratio)		
		Zoonoses from cattle	Zoonoses from small ruminants	Zoonoses from poultry
Modifying factors				
Age (Ref: ≤46 y.o Vs >46 y.o)		1.0 (0.6-1.5)	1.4 (0.8-2.4)	1.0 (0.7-1.5)
Gender (Ref: Female Vs Male)		1.5* (1.0-2.3)	1.2 (0.7-2.1)	1.5* (1.1-2.2)
Experience of rearing/trading: (Ref: ≤5 years)	Cattle (>5 years)	0.8 (0.4-1.4)	0.8 (0.4-1.4)	1.0 (0.7-1.5)
	Sheep (>5 years)	0.6 (0.3-1.3)	0.9 (0.4-2.2)	1.0 (0.6-1.9)
	Goat (>5 years)	1.0 (0.6-1.7)	1.2 (0.6-2.3)	1.1 (0.7-1.6)
	Poultry (>5 years)	1.4 (0.9-2.3)	1.9 (1.0-3.6)	0.8 (0.5-1.2)
Trading connectivity (Ref: K-core 2-3)	K-core 1	1.0 (0.5-2.2)	3.1 (0.8-11.5)	0.7 (0.4-1.5)
	K-core 0	1.4 (0.6-3.4)	2.9 (0.6-14.1)	0.8 (0.4-1.9)
Type of VCAs (Ref: F1)	F2	0.6 (0.3-1.0)	0.3** (0.1-0.7)	0.5** (0.3-0.7)
	T1	4.3* (1.2-15.5)	2.0 (0.3-13.4)	0.5 (0.1-1.6)
	T2	5.6** (1.9-16.7)	1.0 (0.2-1.9)	0.1** (0.03-0.4)
Cue to action (Ref: None)	Other farmers	1.3 (0.7-2.3)	2.2* (1.1-4.5)	2.0* (1.1-3.6)
	Media	0.6 (0.1-2.6)	0.8 (0.1-6.8)	5.4** (1.4-20.5)
	Local authorities	1.2 (0.7-2.2)	1.3 (0.5-2.9)	2.5** (1.4-4.4)
	Other traders	1.0	10.7 (0.4-282.9)	5.4 (0.2-143.6)

Definition:

F1 = Farmers raised specific species (cattle, small ruminants or village chickens); F2 = Farmers did not raise specific species; T1 = Traders traded specific species (cattle, small ruminants or village chickens); T2 = Traders did not trade specific species

7.5.5 Factors affecting self-efficacy on zoonoses by livestock VCAs

Our second model examined the factors influencing the self-efficacy of farmers for zoonoses prevention across different livestock species, including preventive practices for zoonoses transmitted from livestock (i.e. bury dead animals, not eating the carcass of infected animals, hand hygiene, treating sick animal, quarantine the sick animal), perceived barriers (i.e. financial constraints, limited knowledge, limited resources), and residual from the first model (i.e. the unidentified factors on perceived threat) . From our model, the VCAs who would not eat meat from sick cattle were less likely to report that they were confidence managing zoonotic disease risk. Amongst VCAs working with small ruminants, other prevention practices such as zoonoses prevention practice of proper hand hygiene (i.e. cleansing the hand properly after touching, cutting, cooking the meat) and treating the sick animal were positively associated with confidence in prevention of zoonoses transmission ($p<0.05$). Similarly, reported prevention practice of treating sick chickens was also positively associated with the self-efficacy of VCAs on prevention. Similar to self-efficacy on preventing transmissible zoonoses from cattle, limited knowledge was observed as the main factor negatively associated with the self-efficacy of preventing transmissible zoonoses from small ruminants. However, the other factors such as perceived barriers were not significantly different in self-efficacy on prevention of zoonoses transmitted from poultry (Table 7.6).

Table 7.6 Final multilevel mixed effect generalized binomial linear modelling with a random effect of location (villages) to understand the factors affecting confidence in ability of zoonoses prevention of VCAs on zoonotic diseases transmission
*p<0.05; **p<0.01; ***p<0.001

Variable		Confidence in ability of zoonoses prevention (Odds ratio)		
		Zoonoses from cattle	Zoonoses from small ruminant	Zoonoses from poultry
Preventive measures				
Bury dead animal (Ref: No Vs Yes)		1.0 (0.4-2.3)	1.0	0.7 (0.1-5.6)
Eating the carcass of infected animal (Ref: Yes Vs No)		0.2*** (0.1-0.4)	2.2 (0.7-3.7)	2.0 (0.2-17.0)
Hand hygiene (Ref: No Vs Yes)		1.9 (0.6-5.6)	7.7*** (4.1-14.3)	1.6 (1.0-2.7)
Treating sick animal (Ref: No Vs Yes)		1.7 (0.6-4.5)	7.3*** (3.8-13.9)	2.2* (1.1-4.6)
Quarantine the sick animal (Ref: No Vs Yes)		1.0 (0.4-2.9)	2.2 (0.7-7.1)	2.7 (0.9-8.2)
Residuals from the first model (From first model: perceived threat)		414.8** (13.9-12416.1)	3039838*** (63199.3-1.46e+08)	175.1*** (34.3-893.8)
Perceived barrier (Ref: None)	Financial constraint	1.2 (0.4-4.4)	2.9 (0.6-13.7)	2.3 (0.6-8.8)
	Limited knowledge	0.3*** (0.2-0.6)	0.4* (0.1-1.0)	0.5 (0.2-1.0)
	Limit resources	0.4* (0.2-1.0)	0.8 (0.3-2.7)	0.8 (0.2-2.7)

7.6 Discussion

In this study we compared perceptions and practices between farmers and livestock traders in the CDZ with respect to zoonotic risks and investigated the factors associated with perceived threat and self-efficacy practices towards zoonotic risks from their livestock. The factors identified in this study can help support the development of disease prevention and health promotion strategies to enhance the health of farmers and traders under the One-Health paradigm in the CDZ of Myanmar.

Animal movement and trade has been highlighted as an important factor for disease spread (Balkhy and Memish 2003, Fèvre, Bronsvoort et al. 2006). The interaction of farmers and traders through these livestock trade channels could potentially also contribute to the dissemination of information on disease prevention and control. Our results from the social network of livestock movement in the CDZ of Myanmar demonstrate that the livestock trading network in the CDZ is complex and different between stakeholders involved in the livestock trading network. Not surprisingly, our results indicate that the network of livestock movements was significantly more fragmented in the farmer group compared to the trader group. The majority of cattle and village chicken farmers had K-core = 0 which did not belong to the highly connected groups whereas the majority of small ruminant farmers (K-core = 1-2) and traders (K-core = 2-3) showed their contribution in highly connected groups of livestock trading.

While traders of small ruminants also often traded village chickens, the connectivity of these traders was lower compared to traders who traded single species. This might be due to cattle farmers in CDZ raising cattle mainly for draught purpose (Chapter 4) and keeping cattle for longer compared to small ruminants. Even though the literature from Myanmar supporting this finding is not available, another possible reason might be the instability of market price, market demand, accessibility of market or traders, banning due to outbreak, and disease affecting livestock trading (Hurrissa and Eshetu 2002, McDermott, Staal et al. 2010, Musemwa, Mushunje et al. 2008, Oo 2013, 2014). According to the observations during the survey, the Newcastle Disease outbreak in the past two years of the survey caused high mortality in local poultry, and village chicken farmers were not able to sell their birds (Oo 2013, 2014). Nevertheless, due to the high livestock density in CDZ (LBVD 2014), the livestock were widely traded from CDZ to other parts of the country and CDZ could be one of the potential areas for disease spread. Therefore, for the control of disease spread, promoting the awareness of the nodes (i.e. traders and locations) is of paramount importance for the control of regional zoonotic diseases spread through trading.

Previous studies indicate that social background of people (i.e. income, education, religion, race or ethnicity, region, and gender) influences beliefs and perception in many aspects (Harrison, Mullen et al. 1992, Rosenstock 1974, 1990). Our results indicate that social status and occupation are important determinants of the perceived threat of zoonoses for each livestock species. Similar to other studies from developing countries, our study also supports the idea of gender playing a considerable role in the awareness of zoonoses and the perception of risk for different livestock species (Bingham, Budke et al. 2010, Hill, Petty et al. 2012, Macpherson 2005) in that males were 1.5 times more likely to be aware of zoonotic threat than females ($p<0.05$). The observed gender differences may be explained by difference in limiting factors for information access such as education and social status, and further studies are needed to investigate this in more detail. Since Asian countries have been loudly alerted by the threat of Highly Pathogenic Avian Influenza (OIE 2018d), the campaign on transmissible zoonoses from avian species seems to have successfully promoted the awareness of VCAs in the disease threat, with a greater proportion of farmers reporting a perceived disease threat from poultry than other livestock species examined in this study. However, the differences in threats perceived between different animal species was less consistent amongst traders, with a greater proportion perceiving threats from cattle or village poultry than from small ruminants. Another finding from our study highlighted that the VCAs not working with village chickens had less awareness of the zoonoses transmitted from poultry. This finding is consistent for farmers not raising small ruminant, who were less aware of the zoonoses transmitted from small ruminants. Except for cattle diseases, the type of career seems to influence the perception of zoonoses threat transmitted from cattle. Traders, regardless of the livestock species they were working with, were aware of zoonoses from cattle. Other possible reasons might be gender, education, wealth, previous experience of diseases by the traders (Macpherson 2005, Ministry of Health and Demographic and Health Survey Program 2017, OIE 2018e). To explain in this case, a possible reason might be that VCAs gave more attention to the livestock species they were working with and tended to ignore the zoonotic diseases transmitted from other livestock species or the public awareness of zoonotic disease was not widely established to cover all livestock stakeholders regardless of the livestock species they are working with. The frequency of trading and communication with different stakeholders does not seem to promote VCAs' awareness of the zoonoses risk transmitted from livestock. This might be another issue to consider which may lead to the spread of diseases by trading routes due to the lack of awareness of diseases and lack of disease prevention practices.

To investigate determinants of self-efficacy of VCAs on zoonoses prevention, we considered the contribution of perceived threat of risk from each of the species in our study, disease prevention methods and barriers. The results of our study have important implications for the development of future disease control strategies and health promotion policies. First, our findings suggested that factors unaccounted by the perceived threat model are associated with the self-efficacy of VCAs towards zoonotic disease risk from their livestock. While the role of gender showed a significant effect on the perceived threat, we lacked other social factor data to consider in this study. The possible confounding factors such as social status, education and wealth could possibly be related to gender (Filmer and Pritchett 1999, King and Hill 1997). Second, it is not surprising that limited knowledge on prevention was reported as a significant constraint in reducing the VCAs' confidence on disease prevention in this region. The high proportion of VCAs reporting lack of information available can explain this finding. Together, these findings highlight a need for the development and testing of effective public awareness campaigns on zoonoses and prevention methods, including campaigns targeting the provision of information on zoonoses risk, better farm/market biosecurity and prevention methods. Third, our findings suggested even though public awareness on zoonoses seems to be poor due to limited availability of information in the study area, the study population nonetheless practised basic zoonoses prevention methods. What is interesting in the above results is that even though

VCAs reported a number of prevention methods to prevent disease transmission from cattle, none of them seemed to significantly promote self-efficacy. Nevertheless, the prevention practice to prevent diseases transmitted from small ruminants and poultry seem to effectively promote the self-efficacy of VCAs.

A number of study limitations need to be considered to assist the interpretation of our findings. Firstly, these findings are limited by the use of cross sectional design and are not able to identify the perception on zoonoses of the livestock stakeholders over time. Secondly, the sample was aimed to be representative of the different livestock stakeholders in the CDZ of Myanmar but for trader groups, the data collection was able to be conducted only by means of targeted and convenience sampling so that we might have missed some of the people and selection bias was unavoidable. Thirdly, even though structural models implementing causal path-like relationships of the Health Belief framework with at least four levels of perception or awareness in each component has been used for most of the Health Belief model studies (Valeeva, van Asseldonk et al. 2011), we used an adapted structural Health Belief framework with two levels of perception or awareness in each Health Belief component in our study. Fourth, this study was unable to identify the effect of social factors such as wealth, education and social status. Despite these shortcomings the current findings add to a growing body of literature on the perceptions of different stakeholders in the CDZ of Myanmar on zoonotic disease.

7.7 Conclusions

The present study was designed to understand the perceptions of livestock farmers and traders on zoonoses prevention and transmission and thereby identify opportunities to improve the control of animal and zoonotic diseases, and to limit disease transmission through livestock marketing networks. Overall, our findings successfully measure the limited knowledge on zoonoses and highlight the need to strengthen provision of information on zoonoses prevention methods possibly through media and local authorities. Though the current study was not describing a specific disease, the current findings add to a growing body of literature on perception of different livestock VCAs in the CDZ of Myanmar on generalized zoonotic diseases. If the debate is to be moved forward, a better understanding of perception of farmers on important specific zoonotic diseases needs to be developed.

CHAPTER 8

GENERAL DISCUSSION

8.1 Significance of the study

The body of research comprising this thesis is unique in the following ways: firstly, this is the first detailed, thoroughly designed and conducted study that focusses on livestock health and production in Myanmar; secondly this research highlighted the importance of multispecies rearing for small-scale farmers in Myanmar; and thirdly this is the first scientific study that explores the interaction between livestock species raised within a household and their impact on income, sharing of limited resources, livestock management, livestock disease prevention and the prevention of zoonotic diseases.

To understand the significance of this research, the importance of livestock for the rural farmers in Myanmar has to be considered. Approximately 68% of Myanmar's total population rely on income generated from livestock and crops (MOALI, FAO et al. 2018), but the poverty rate is higher in rural areas (i.e. villages and farms) (38.8% of the rural population, or 13.8 million people) compared to towns and cities (14.5% of the urban population or 2 million people) (Ministry of Planning and Finance and World Bank 2017a). Despite the establishment of measures for poverty alleviation by the Myanmar government, progress is slow in rural regions while living standards have improved rapidly in urban areas (Ministry of Planning and Finance and World Bank 2017b). The highest concentration of people classified as living below the poverty line are found in the CDZ (65% of the population classified as poor) and in the Ayeyarwaddy Delta (Ministry of Planning and Finance and World Bank 2017a). _In addition, the probability of self-reported sickness in the CDZ is one of the highest in Myanmar (Ministry of Planning and Finance and World Bank 2017a).

Therefore, improved livestock production will help to increase the income of rural farmers, and will also help to contribute to rural development and poverty alleviation and increase the country's income from livestock production (which is estimated to be 10% of national income) (Global Agriculture and Food Security Program 2016, MOALI, FAO et al. 2018, United Nations Development Programme 2004a). Furthermore, as 70% of income in rural households is spent on food (Central Statistical Organization 2012), improving livestock production through better husbandry, biosecurity and health management would support food security, food safety and nutrition of the people in the CDZ and in Myanmar (Global Agriculture and Food Security Program 2016).

8.2 Key findings

Research question 1: What are the ownership patterns for various livestock species and what management and husbandry practices are used by small-scale livestock farmers in the CDZ of Myanmar?

8.2.1 Livestock ownership (Chapter 4)

Multispecies livestock production (i.e. rearing more than one species in the same household) is very common in Myanmar and this has also been observed for small-scale farmers in other developing countries (IGS Budisatria, HMJ Udo et al. 2007, FAO 2009, Kristjanson, Krishna et al. 2004, Morand-Fehr and Boyazoglu 1999). Multispecies rearing presents a number of benefits to farmers such as 1) reducing economic risk associated with keeping single livestock enterprises that could be affected by disease or mortality, 2) providing different income sources derived from livestock production that can be utilized throughout the year (e.g. village chickens provide quick disposable income at any time of year, while sale of small ruminants is probably conducted with more profit-orientated intentions at specific times of the year), 3) optimizing the use of husbandry resources by sharing animal housing and 4) diversifying the household income for more security in maintaining livelihood of farmers. Our study also demonstrates that the raising of village chickens in combination with cattle or small ruminants was more common than the combination of small and large ruminants. This is probably because chickens are managed easily, and do not compete for ruminant resources.

8.2.2 Purpose of livestock rearing (Chapter 4)

Livestock species are reared for different purposes in Myanmar, which is consistent with subsistence farming observed in less mechanised agriculture production systems of developing countries (Chawatama, Mutisi et al. 2005, Choprakarn and Wongpichet 2007, Devendra and Thomas 2002a, 2002b, Henning, Pym et al. 2007, Kahan 2003, Lawrence and Pearson 2002). Cattle (in particular pairs of adult males) are the major source of draught power for crop production and are limited for use in breeding, production of milk and meat production. Small ruminants are sold as adults for meat production, while village chickens are sold for meat, but also present an important protein source for home consumption and a small proportion of farmers kept village chickens for cock fighting.

8.2.3 Feeding of livestock (Chapter 4)

Feeding practice in livestock production in the CDZ was mainly dominated by grazing or free-range practice. Cut-and-carry grass and concentrated supplementary feed (e.g. groundnut cake, sesame cake, etc.) were predominantly supplied to draught cattle and less frequently to cattle raised for other purposes (i.e. meat production, milking or multiple purposes) or the other livestock species studied here (i.e. small ruminants and village chickens). Livestock farmers may not be fully aware of the benefit of the supplementary feeding, they may not obtain the expected benefits when practising supplementary feeding or the provision of supplementary feed is perhaps not affordable for some farmers. In addition, seasonal variation in the provision of feed was noted for cattle, due to the shortage of feed in the hot season (i.e. March to May) whereas no seasonality in nutritional management was observed for small ruminants and village chickens. The provision of freshly cut grass and supplementary feed is expensive for cattle farmers and therefore owners of larger cattle herds prefer the practice of grazing cattle. Interestingly, drinking water was mainly provided to larger village chicken flocks, suggesting that adequate care focussed on larger, more valuable flocks.

8.2.4 Housing of livestock (Chapter 4)

Livestock of higher value (i.e. cattle and small ruminants) were given extra attention in regard to the provision of shelters. These shelters were built using simple, readily available materials in the environment (i.e. leaves, bamboo, etc.) and were mainly used to confine livestock to a single place and prevent the loss of animals, rather than for improving biosecurity and limiting disease transmission. Reducing disease transmission through appropriate housing did not seem to be a major concern of local farmers in the study area.

8.2.5 Breeding management of livestock (Chapter 4)

Using males from the same village or other villages was more common in the management of the breeding cattle breeding compared to small ruminants. The commonly observed inbreeding in small ruminants is supported by confining small ruminants together as one flock on farm premises. Larger small ruminant flocks were also more likely to use their own males for breeding, rather than males from other flocks. This might be explained by farmers having poor awareness of inbreeding and preferring the convenience of using their own males rather than finding males outside of the farms. This condition is similar to other developing countries (Jaitner, Sowe et al. 2001, Kahi, Rewe et al. 2005). Artificial insemination is not commonly conducted and was only observed in few cattle owning farms. In addition, castration was more common in cattle households compared to small ruminant households, but usually, older cattle were castrated, which is a concern in regard to animal welfare, occupational health and safety in conducting the castration, and the potential healing process following the castration.

8.2.6 Herd or flock size (Chapter 4)

Our study confirmed that the numbers of livestock raised are small, with a median cattle herd sizes of 4 animals (IQR: 2-7), small ruminant herd sizes of 30 (IQR: 15-41) and village chicken flock sizes of 10 (IQR: 5-18). Interestingly, there was no significant difference ($p>0.05$) in the proportion of households with ‘Small, ‘Medium’ or ‘Large’ herds/flocks of cattle, small ruminants or village chickens across the different livestock ownership groups.

Larger cattle herds were more likely to employ labour from outside the household to manage cattle than medium or small herds, highlighting the demand for additional labour for larger herds. As larger cattle herds were also more likely to contain cows and calves (rather than just draught cattle), there is a demand for appropriate trained labour to conduct calf-cow management within cattle farms.

Research question 2: What are the livestock health problems, health management and disease prevention practices conducted on small-scale cattle, small ruminant and village chicken farms in the CDZ of Myanmar?

8.2.7 Syndromic health problems of livestock (Chapter 5)

In this study we used a syndromic approach to summarize health problems in cattle, small ruminant and village chicken farms and described associations between husbandry practices and animal health problems affecting different body systems. Health problems associated with physical, respiratory and digestive body systems are common in livestock species and many of these clinical signs are consistent with FMD in cattle and small ruminants and ND village chickens – a high incidence of these diseases has been reported by LBVD in the CDZ of Myanmar. Other diseases such as anthrax, black quarter, haemorrhagic septicaemia and HPAI were also frequently reported in the CDZ and Myanmar (Oo 2013, 2014) and cross-species disease transmission between ruminant species is likely to occur.

8.2.8 Livestock health management (Chapter 5)

Approximately 60-70% of village chicken and small ruminant owners did not implement any specific biosecurity measures to reduce the spread of livestock diseases, in contrast to about 30% of cattle owners. If treatment was conducted, the majority of the small ruminant and village chicken owners relied on traditional medicine, while the majority of cattle farmers used veterinary health care providers.

We also developed a biosecurity and livestock disease prevention index (BDPI) that can be compared between livestock species. This index was developed by taking into account health management practices such the provision of treatment to sick animals, vaccinations against common livestock diseases, sanitation practice and other preventive measures to reduce the transmission of infectious livestock diseases. Cattle owners conducted better biosecurity and disease prevention practices (cattle median BDPI: 45) compared to small-ruminant and village chicken farmers (small ruminant and village chicken BDPI: 10). This highlights that farmers gave more attention to high value animals in regards to disease control. Health problems and biosecurity practices were not associated with different livestock ownership combinations on small ruminant and cattle farms. However, on village chicken farms, poor biosecurity practices were more common amongst multispecies-rearing households, as the BDPI was lower when chickens were kept with other livestock species.

8.2.9 Income obtained from livestock production (Chapter 5)

In general, small-scale farmers who raised more than one livestock species seem to earn higher income than farmers raising a single livestock species. Types of income obtained from livestock species differed between types of livestock. For cattle owning households, cattle supported the income derived from crop production, as they were used for draught power during field preparations. Small ruminants and village chickens were raised for the sale of animals. However, village chickens contributed more substantially to nutritional benefits, as chickens and their eggs were also frequently consumed. Surprisingly, in small ruminant-owning households, greater livestock income occurred in herds/flocks that experienced respiratory or digestive problems. One explanation could be that the farmers tend to sell unwell animals rather than treat them, due to the farmers' poor understanding of disease management or their inability to fund disease management.

In addition, village size was associated with farm income, with lower income from livestock production observed in smaller villages compared to larger villages. Sale prices of livestock are lower in smaller villages, which often have poorer infrastructure and road networks and are further away from main roads. Due to the poorer infrastructure and distance to travel, farmers in smaller villages might be less likely to be able to travel to markets and are forced to rely on traders visiting their villages. Similarly, travel for traders to these villages is more costly and time consuming, making efforts worthwhile only if they offer lower sale prices.

Farmers in larger villages are also more likely to have access to resources for disease prevention (e.g. vaccination) (Chapter 6), thus they were more likely to practise better livestock management which led to earning a higher income from livestock production.

Research question 3: Which factors influence small-scale farmers' decisions to implement disease prevention practices and vaccinate livestock against Foot and Mouth Disease (FMD) and Newcastle Disease (ND) in the CDZ of Myanmar?

8.2.10 Factors influencing small-scale farmers' decisions to vaccinate their animals against common infectious livestock diseases (Chapter 6)

The majority of livestock farmers were aware of the risk of FMD and ND and the impact of these diseases and 88% of cattle farmers, 84% of small-ruminant farmers and 71% of village chicken farmers were willing to vaccinate their animals. However, a major constraint was that about 17.0% of cattle, 2.3% of small ruminant and 15.4% of village chicken owners indicated the non-availability of vaccinations in their villages. Twice as many small ruminant farmers compared to cattle and village chicken farmers indicated they had no funds to conduct vaccinations. Local authorities were the main provider of information on disease prevention and vaccinations (although less frequently on ND prevention in village chickens), while traders were an important additional source of information about FMD vaccinations for small ruminant farmers. Larger villages with larger populations and better accessibility were more likely to be provided with information and vaccinations compared to smaller villages. Veterinary authorities gave more attention to the provision of information on FMD prevention in cattle compared to other livestock species despite the ubiquitous threat of diseases affecting various livestock species (Win 2017).

This probably leads to a stronger interest by farmers to have their cattle vaccinated, compared to other livestock species, but as the mortality rate for FMD is generally low, the actual proportion of cattle being vaccinated was low, suggesting farmers ultimately gave vaccination little importance. Overall across all livestock species, perceptions on the effectiveness of vaccination, poor knowledge about the use of vaccination and limited availability of vaccine and vaccinators limited the willingness of farmers to conduct vaccinations, while the perceived detrimental impact of the diseases increased farmers' willingness for preventive actions.

Research question 4: What attitudes, beliefs and barriers of livestock farmers and traders and trading practices are associated with the implementation of methods to prevent zoonotic disease transmission?

8.2.11 Perceptions of livestock value chain actors (VCAs) on the risk of acquiring zoonotic diseases from their livestock (Chapter 7)

In this study we investigated attitudes, beliefs and barriers to the application of recommended zoonotic disease prevention among livestock farmers and livestock traders. The majority of farmers and traders (>85%) reported that they did not practise any preventive measures. For zoonotic diseases transmitted from cattle, the practice of burying dead animals and keeping sick animals away from humans was more common in farmers than traders. For zoonotic diseases transmitted from small ruminants, burying the dead animals was more common in traders than farmers. Male value chain actors (i.e. both farmers and traders) were 1.5 times more likely to be aware of the zoonotic threats than female VCAs.

Farmers and traders not handling small ruminants and/or poultry were less likely to be aware of zoonotic risks associated with these animals. Farmers were more likely to access information on zoonotic risks than traders for all three livestock species studied. Information on zoonotic diseases that can be obtained from poultry was disseminated through farmers, local authorities and the media while information on zoonoses that can be transmitted through small ruminants was mainly disseminated through farmers. Although traders reported a number of preventive methods to reduce disease transmission in cattle, none of them seem to conduct these preventions. Nevertheless, appropriate hand hygiene measures (i.e. cleaning of hands after touching, cutting, cooking meat) and treating of sick animals increased the confidence of small ruminant and village chicken owners to prevent zoonotic diseases.

A greater proportion of farmers indicated a perceived disease threat from poultry compared to other livestock species, probably due to the widely conducted information campaigns on avian influenza. The most common zoonotic diseases that farmers are aware of being transmitted from livestock are anthrax and avian influenza (data obtained in informal interviews and not shown here). Although the farmers reported a high frequency of reproductive problems in cattle and small ruminants, brucellosis as a potential zoonoses was not described by farmers. In general, people working with livestock might not be fully aware of zoonotic diseases and their public health impact. This might be due to low levels of literacy and education (Ministry of Health and Demographic and Health Survey Program 2017).

Both farmers and traders are aware of the zoonotic diseases that can be transmitted from the species they are raising or trading, but they are unaware of zoonotic diseases that can be transmitted from other species they are not raising or trading. A greater proportion of traders seem to more aware of the threat of zoonoses transmitted from cattle compared to cattle farmers. However, demographic factors of traders such as gender, education, wealth, previous experience with diseases, which were described in previous studies (Macpherson 2005, Ministry of Health and Demographic and Health Survey Program 2017, OIE 2018e) were not identified in the current research to be associated with the zoonotic diseases awareness of traders.

8.3 Conclusions

- Current strategies for livestock development in Myanmar focus strongly on developing dairy cattle production and setting up larger commercial farms. But our study suggests that the purpose of raising livestock in Myanmar is still very traditional and has not changed over the past decade (Oo 2010), for example with cattle kept mainly for draught purpose to support income generation from cropping. Thus, government strategies to improve animal health and production need to consider that the majority of all livestock in Myanmar are still raised under traditional conditions and therefore small-scale farmers should be a priority in policy developments (Global Agriculture and Food Security Program 2016). In addition, international development projects such as those funded by USAID, ACIAR, WORLDBANK and GIZ, also focus on livestock production of small-scale producers (ACIAR 2013, FAO 2011b, 2011c, JICA 2015, MOALI, FAO et al. 2018, van der Lee and de Jong 2014, Win 2017).

- Vaccinations against livestock diseases are organised by the livestock department and most vaccinations are provided by the livestock department free of charge (Personal communication with Kyaw Naing Oo and Win Myint Thein), but unfortunately the more remote villages are often not reached (Chapter 6). Thus, some livestock might not be vaccinated through government campaigns. To counteract this, perhaps the use of private veterinarians to conduct vaccinations should be considered. This of course means a paradigm shift, from government to private veterinarians, and also livestock farmers would be required to pay for these private services.

- Vaccines against the most common livestock diseases are produced by government departments, but depending on resources provided, the number of doses produced and then distributed might vary between years. For example, Newcastle Disease I-2 production was manufactured across five vaccine laboratories in Myanmar but is currently only produced in the Yangon laboratory for the conventional vaccination programme (Personal communication with Kyaw Naing Oo). The 'potency' and 'coverage' seem to be low in the usage of vaccine and a sporadic outbreak has been reported within the region. In addition, the current department has not used any research evidence and follow-up monitoring and evaluation to check the effectiveness of the use of vaccine and economic impact has not been seen to be implemented.

- Some farmers in this research seemed to have had negative experiences with vaccinations, and potentially, the 'potency' of these vaccines could have played a role. Expiry dates of the vaccines and perhaps also quality of vaccines produced in other South-East Asian countries need to be considered (Garland 1999, Sakamoto, Morioka et al. 2016, Sieng, Walkden-Brown et al. 2018, Solyom, Fazekas et al. 1980).

- Welfare issues should be considered. Welfare issues that are associated with larger livestock enterprises, such as cannibalism and crowding-associated diseases, are less relevant for small-scale farmers. However other issues such as tethering of animals and perhaps neglect of requirements of animals under harsh climatic conditions (e.g. no or limited provision of water) might be common for small-scale producers (Fraser 2008, Fraser, Weary et al. 1997, Korte, Olivier et al. 2007, Silanikove 2000).

- The human-animal health connection in small scale farms can be considered to be very strong, as animals are raised in close contact with all family members and also in close proximity to the living areas of farmers. However, the close contact with livestock on small-scale farms brings a number of public health risks with transmission of livestock disease through contact by direct handling, birthing of offspring, treatment of infected areas or the consumption of animal products which need to be considered (Cosivi, Grange et al. 1998, Osbjer, Boqvist et al. 2015, Taylor, Latham et al. 2001a).

- Shortage of labour is one of the constraints to increase cattle herd sizes. Due to migration of young people to urban areas or other neighbouring countries, human resources and labour availability for livestock production is limited. There is an inequality in economic development between urban and rural areas in Myanmar, resulting in an increased demand for labour and employment in urban areas and young adults from rural areas tend to leave their rural community (United Nations Development Programme 2004b). This has a negative impact on agriculture which requires 56% of the country's workforce due to the limited use of mechanization (Raitzer, Wong et al. 2015). Migration of people to neighbouring countries (such as Thailand, China, Malaysia and Singapore) for work largely attracts young people away from local farm work and has devastating effects on the human resources within Myanmar for both the agriculture and industrial sector (Phyo, Grünbühel et al. 2016). This results in older people, women and young children becoming the main sources of labour for livestock production. Furthermore, women are often the care-taker of animals by feeding, treating and having close contact with them which is similar to other developing countries (Amin, Ali et al. 2010, Ayoade, Ibrahim et al. 2009, Niamir-Fuller 1994, Ogunlela and Mukhtar 2009, Sinn, Ketzis et al. 1999). In particular, village chickens are mainly managed by women and children and provide an important resource for promoting rural development through promoting empowerment and income for women.

- Poor communication techniques of local veterinary authorities for efficiently promoting awareness of methods of disease prevention and better productivity to farmers, along with limited communication between local livestock farmers and local veterinary authorities for health problems is another considerable factor in livestock health management in CDZ.

- In Myanmar, conducting nutritional interventions for poultry make subsequent interventions for small ruminants and cattle in the same household as the extension practice on multispecies still rare. As our study pointed out that more than half of the total sample population raised multispecies rearing (Chapter 4), it would be beneficial to practice extension on sustainable and affordable nutritional practice and cross-species disease control for the majority of the livestock farmers.

- To promote long-term projects for sustainable disease prevention and livestock development, extension work and public awareness campaigns are required. In Myanmar and especially in the CDZ, a number of livestock development projects focussing on FMD and ND vaccination, dairy development, livelihood improvements from livestock production and a livestock census have been implemented by different international organizations in collaboration with LBVD. Such organisations include FAO, OIE, LIFT, USAID, JICA, KOICA, NZAid, ACIAR (ACIAR 2013, FAO 2011b, 2011c, JICA 2015, MOALI, FAO et al. 2018, van der Lee and de Jong 2014, Win 2017). The data collected in this research will be useful to inform, design and refine future livestock development activities.

- These researches presented here identified limited awareness towards livestock diseases and control practices amongst cattle, small ruminant and village chicken farmers. This highlights that appropriate extension messages need to communicate farmers. The extension work should highlight the clinical presentation and the economic impact of important livestock diseases, such as FMD and ND (Dumesnil and Verger 2009, Henning, Hla et al. 2014, Oo 2010), while also informing about livestock disease prevention approaches. A practical approach would to combine large-scale disease control campaigns with focussed extension work. For example, government-organised livestock vaccination programme alone might be insufficient to increase farmers' awareness to prevent livestock diseases and it is recommended that extension should be conducted along with vaccination campaigns.

- Record keeping and a reporting system of clinical signs observed in livestock should be promoted by providing booklets in a recommended format to small-scale farmers. However, to establish such a practice, incentives such as monthly medical clinical examinations of livestock through township veterinarians are recommended. In addition, the number of animals sold and prices of animal sales should be recorded. However, one concern for livestock farmers might be the recently developed income tax system in Myanmar (Hluttaw 2017) and as they might fear to pay levy tax based on their recording of livestock sales.

- Information campaigns on improving animal health, such as education campaigns about vaccinations and bio-security conducted for small-scale households in Myanmar should consider the multi-species livestock rearing structure. A major cost in education campaigns is reaching the villages, therefore extension work should cover all livestock species raised in the villages. For example, information on diseases of importance for cross-species transmission (such as FMD for cattle and small ruminants) should accompany vaccination campaigns on FMD, that might have been designed for cattle. On the other hand, campaigns should be used to educate farmers as a whole. For example, if it is planned to increase awareness information on brucellosis in small ruminants, such campaigns could also include information on poultry that are kept within the same premises.

- Appropriate communication strategies, which include the traditional Dutaik meeting approach (Oo 2010) should be used to identify barriers for disease prevention. Considering the varied literacy of farmers, visual, oral and written communication methods should be considered, including the use of cartoons, flip charts, photos, video recordings, and the provision of detailed booklets (Chansrichavala, Wongsuwan et al. 2015, Dewapura 1994, Grady 2007, Lunch and Lunch 2006). Posters or billboards displaying key extension messages on improved husbandry practices and disease control (Earnshaw, Monnet et al. 2009, Miyamatsu, Okamura et al. 2013) could be erected in publicly accessible areas (i.e. village headman's houses, schools, markets, tea shops, main roads). In particular, the distribution of vaccination calendars indicating the timing (month or season and time intervals) of vaccinations for different livestock species is highly recommended.

- Media (radio, television and newspapers) is one of the most effective methods to increase public awareness on livestock diseases and zoonoses (Amarasinghe, Usgodaarachchi et al. 2010, Dewapura 1994, Kurita, Nakamura et al. 2006, Sampei and Aoyagi-Usui 2009). In addition, implementing a hotline phone system (Fink 1989, Ivatury, Moore et al. 2009) is recommended to provide information on livestock diseases to farmers, including disease control and prevention methods, Q&A support, advice to solve husbandry and disease problems, outbreak reporting and to receive contact details of the nearest livestock veterinarian.

- Animal health apps are more and more used in developed countries (Beyene, Asfaw et al. 2018, Mosa, Yoo et al. 2012) and might provide an opportunity to distribute information to farmers and promote the real-time data reporting system in Myanmar. Even though Myanmar Posts and Telecommunications launched mobile telecommunication services in December 1993, the use of mobile technology was very limited in the initial years due to the expense of SIM cards (US$ 1,500). Myanmar only opened up to the mobile telecommunication market in the last decade. Due to market competition, the price of local SIM cards has fallen to approximately US$ 1-1.5 (Go Myanmar Tours 2018, Myanmar

Posts and Telecommunications 2018, Nam, Cham et al. 2015). Now almost all farmers have mobile phones and are able to recharge their phones in their village.

8.4 Limitation of the study

Firstly, our study only focused on the most common livestock species in the CDZ which are cattle, small ruminants (i.e. sheep and goat), and village chickens, but other livestock species such as pigs and ducks are also raised in these areas. Thus, livestock management and health results are only applicable to the three-livestock species studied. However, we expect that human attitudes towards disease prevention and the control of zoonotic disease might be similar in pig or other poultry-owning households.

Secondly, data collection for this research was conducted in cross-sectional studies, thus data were collected at a single point in time. Although we tried to obtain some seasonal information based on farmers' and traders' recall, we did not actually monitor the seasonal variation of variables such as observed disease symptoms and sale prices over time. Furthermore, the data collected on husbandry practices and animal health problems focussed on the one-year period before the interviews, while some information collected from traders covered a two-year period to cover variation in sales which was then converted into one-year data. Overall, due to lack of data recording by farmers and traders, all data collected was based on memory recall.

Thirdly, we used a syndromic approach to identify the occurrence of livestock health problems as farmers were often unable to diagnose specific livestock diseases. We also did not confirm the occurrence of livestock diseases through clinical examination by experienced veterinarians or through the use of specific diagnostic tests. Thus, using the syndromic approach was a compromise to compile data on the occurrence of animal health problems.

Similarly, we were unable to use triangulation to confirm if the vaccinations, biosecurity measures and zoonotic disease prevention practices outlined by farmers were actually practised and conducted by farmers. However, we tried to confirm supplementary questions during the data collection, if the practices and approaches were in fact conducted as outlined by farmers.

Furthermore, we used different approaches for selecting farmers and traders in the cross-sectional surveys. As lists of villages and farmers were compiled in the preparation of the cross-sectional survey, we could use random sampling to identify livestock farmers. However, we were unable to compile a list of traders and had to rely on a convenience sample of traders to interview, which could, potentially, introduce some selection bias. However, we were able to interview all main small ruminant and village chicken traders in the two townships of our study area, while we interviewed a selection of cattle traders, livestock middlemen and hawkers.

We tried to obtain ordinal responses from farmers and traders while exploring their perceptions and attitudes towards disease and zoonotic disease prevention using the health belief framework. However, as variation of responses was very limited, we had to dichotomize the responses for further analysis, which might have limited the interpretation of our results, but it was the most appropriate analytical approach for the data available.

8.5 Recommendations for further studies and final remarks

Future research on livestock production and health in Myanmar could build on the results presented here and could focus on:

- Longitudinal data collection and diagnostic testing of animals and/or clinical examination to confirm the disease status
- Research of specific disease syndromes identified here
- Research on pigs and other poultry species
- Economic analysis, value chain and livelihood analysis of multispecies rearing households
- Intervention studies to explore the use of specific management practices to improve production and/or health

The current study 1) identified the constraints and opportunities to improve livestock productivity and health and thereby increase the livelihoods of small-scale farmers that are derived from livestock production; 2) summarized the perception of small-scale livestock farmers on methods to prevent common livestock disease; 3) evaluated the attitudes and practices of small-scale livestock farmers and traders to prevent the transmission of zoonotic diseases from livestock. The findings from this research will support the development and strategies outlined by international organisations for “self-sufficiency in livestock products and production of exports for surplus” and “socio-economic development of householders in the livestock sector” (United Nations Development Programme 2004a) supporting the aim that “by 2030, Myanmar achieves inclusive, competitive, food and nutrition secure, climate change resilient, and sustainable agricultural system contributing to the socio-economic well-being of farmers and rural people and further development of the national economy” (MOALI, FAO et al. 2018).

APPENDICES

Annex 1 Ethical approval for the first field trip provided by Behavioural and Social Science Ethical Review Committee

THE UNIVERSITY OF QUEENSLAND

Institutional Human Research Ethics Approval

Project Title:	Identification of Constraints and Opportunities for the Trade and Marketing by the Small-Scale Producers in the Central Dry (CDZ) of Myanmar
Chief Investigator:	Dr Tu Tu Zaw Win
Supervisor:	Dr Joerg Henning, Dr Ricardo Soares Magalhaes, Dr Angus Campbell, Dr Kyaw Naing Oo
Co-Investigator(s):	None
School(s):	School of Veterinary Science
Approval Number:	2014001425
Granting Agency/Degree:	PhD
Duration:	31st October 2018

Comments/Conditions:

Expedited Review - Low Risk

Note: If this approval is for amendments to an already approved protocol for which a UQ Clinical Trials Protection/Insurance Form was originally submitted, then the researchers must directly notify the UQ Insurance Office of any changes to that Form and Participant Information Sheets & Consent Forms as a result of the amendments, before action.

Name of responsible Committee:
Behavioural & Social Sciences Ethical Review Committee
This project complies with the provisions contained in the *National Statement on Ethical Conduct in Human Research* and complies with the regulations governing experimentation on humans.

Name of Ethics Committee representative:
Associate Professor John McLean
Chairperson
Behavioural & Social Sciences Ethical Review Committee

Signature

Date 22/10/2014

Annex 2 Ethical approval for the second field trip provided by Behavioural and Social Science Ethical Review Committee

THE UNIVERSITY OF QUEENSLAND

Institutional Human Research Ethics Approval

Project Title:	Identification of Constraints and Opportunities for the Trade and Marketing by the Small-Scale Producers in the Central Dry (CDZ) of Myanmar - 23/01/2015 - AMENDMENT
Chief Investigator:	Ms Tu Tu Zaw Win
Supervisor:	Dr Joerg Henning, Dr Ricardo Soares Magalhaes, Dr Angus Campbell, Dr Kyaw Naing Oo
Co-Investigator(s):	None
School(s):	School of Veterinary Science
Approval Number:	2014001425
Granting Agency/Degree:	PhD
Duration:	31st October 2018

Comments/Conditions:

Note: if this approval is for amendments to an already approved protocol for which a UQ Clinical Trials Protection/Insurance Form was originally submitted, then the researchers must directly notify the UQ Insurance Office of any changes to that Form and Participant Information Sheets & Consent Forms as a result of the amendments, before action.

Name of responsible Committee:
Behavioural & Social Sciences Ethical Review Committee
This project complies with the provisions contained in the *National Statement on Ethical Conduct in Human Research* and complies with the regulations governing experimentation on humans.

Name of Ethics Committee representative:
Associate Professor John McLean
Chairperson
Behavioural & Social Sciences Ethical Review Committee

Signature ____________ Date 28/1/2015

Annex 3 Summary of research studies that describe factors affecting livestock production

No.	Factors affecting livestock production	Constraint	Opportunities	Type of Species	Regions
1.	Disease occurrence (mainly based on national statistics, one-off serological or syndromic investigations)	X		Livestock	Zimbabwe (Chawatama, Mutisi et al. 2005) Developing regions (McDermott, Staal et al. 2010, Steinfeld 2003) South Asia (Thomas, Zerbini et al. 2002)Eastern DR Congo (Maass, Katunga Musale et al. 2012) Ethiopia (Amenu, Markemann et al. 2013)
		X		Poultry	Myanmar (Henning, Pym et al. 2007)
2.	Access to capital/ Financial barriers	X		Livestock	Zimbabwe (Chawatama, Mutisi et al. 2005) Developing regions (Steinfeld 2003) South Asia (Thomas, Zerbini et al. 2002) Eastern DR Congo (Maass, Katunga Musale et al. 2012)
3.	Lack of grazing area	X		Livestock	South Asia (Thomas, Zerbini et al. 2002) Zimbabwe (Chawatama, Mutisi et al. 2005) Sri Lanka (Samarajeewa, Schiere et al. 2003)
4.	Access to markets	X		Livestock	Zimbabwe (Chawatama, Mutisi et al. 2005)
5.	Gender imbalance	X		Livestock	Developing regions (Steinfeld 2003) Zimbabwe (Chawatama, Mutisi et al. 2005)
6.	Training on livestock production system	X		Livestock	Zimbabwe (Chawatama, Mutisi et al. 2005)
7.	Poor animal genetic resources	X		Livestock	South Asia (Thomas, Zerbini et al. 2002, Vercoe 1997) (Assam) India (Mazumder, Kalita et al. 2014) Malawi (Tebug, Kasulo et al. 2012)
8.	Scarcity of good quality feed resources	X		Livestock	South Asia (Thomas, Zerbini et al. 2002, Vercoe 1997) Asia, Africa (Chander, Bodapati et al. 2011, McDermott, Staal et

No.	Factors affecting livestock production	Constraint	Opportunities	Type of Species	Regions
					al. 2010) Eastern DR Congo (Maass, Katunga Musale et al. 2012) Malawi (Tebug, Kasulo et al. 2012) Ethiopia (Amenu, Markemann et al. 2013) Kenya (Bebe 2003)
9.	Inadequate transport availability	X		Livestock	South Asia (Thomas, Zerbini et al. 2002) (Assam) India (Mazumder, Kalita et al. 2014) Eastern DR Congo (Maass, Katunga Musale et al. 2012)
10.	Poor availability of skilled labour	X		Livestock	South Asia (Thomas, Zerbini et al. 2002) (Assam) India (Mazumder, Kalita et al. 2014) World (Hemme and Otte 2010) Sri Lanka (Samarajeewa, Schiere et al. 2003)
				Small ruminants	World (Udo, Aklilu et al. 2011)
11.	Processing facilities	X		Livestock	South Asia (Thomas, Zerbini et al. 2002)
12.	Poor storage facilities	X		Livestock	South Asia (Thomas, Zerbini et al. 2002)
13.	Delivery of advisory	X		Livestock	South Asia (Thomas, Zerbini et al. 2002)
14.	Inadequate veterinary services	X		Livestock	South Asia (Thomas, Zerbini et al. 2002) Eastern DR Congo (Maass, Katunga Musale et al. 2012) (Assam) India (Mazumder, Kalita et al. 2014) Zimbabwe (Chawatama, Mutisi et al. 2005) Malawi (Tebug, Kasulo et al. 2012) Ethiopia (Amenu, Markemann et al. 2013)
15.	Poor infrastructure	X		Livestock	South Asia (Chander, Bodapati et al. 2011, Thomas, Zerbini et al. 2002, Vercoe 1997)
16.	Lack of knowledge on proper (scientific) management	X		Livestock	South Asia (Chander, Bodapati et al. 2011, Thomas, Zerbini et al.

No.	Factors affecting livestock production	Constraint	Opportunities	Type of Species	Regions
					2002, Vercoe 1997) (Assam) India (Mazumder, Kalita et al. 2014) Malawi (Tebug, Kasulo et al. 2012)
17.	Poor sanitary regulations	X		Livestock	Tropical countries (Chander, Bodapati et al. 2011)
18.	Traceability	X		Livestock	Tropical countries (Chander, Bodapati et al. 2011)
19.	Technical barriers	X		Livestock	Developing regions (McDermott, Staal et al. 2010, Steinfeld 2003) (Assam) India (Mazumder, Kalita et al. 2014)
20.	Social/ culture barriers	X		Livestock	Developing regions (Steinfeld 2003)
21.	Education	X		Livestock	Developing regions (Steinfeld 2003)
22.	Lack of property rights	X		Livestock	Developing regions (Steinfeld 2003)
23.	Lack of competitiveness	X		Livestock	Developing regions (Steinfeld 2003)
24.	Production cost	X		Livestock	Developing regions (Steinfeld 2003)
25.	Transaction cost	X		Livestock	Developing regions (Steinfeld 2003)
26.	Market risk	X		Livestock	Developing regions (Steinfeld 2003)
27.	Production risk	X		Livestock	Developing regions (Steinfeld 2003)
28.	Policies and institution for livestock development		X	Livestock	Developing regions (Steinfeld 2003)
29.	Create the conditions to overcome barriers in livestock production		X	Livestock	Developing regions (Steinfeld 2003)
30.	Enhancing the rural livelihood		X	Livestock	Developing regions (Steinfeld 2003)
31.	High cost of concentrated feed	X		Livestock	(Assam) India (Mazumder, Kalita et al. 2014)

No.	Factors affecting livestock production	Constraint	Opportunities	Type of Species	Regions
32.	Non availability of feed and fodders	X		Livestock	(Assam) India (Mazumder, Kalita et al. 2014)
33.	Lack of departmental coordination	X		Livestock	(Assam) India (Mazumder, Kalita et al. 2014)
34.	Social system norm	X		Livestock	(Assam) India (Mazumder, Kalita et al. 2014)
35.	Non receipt of subsidy	X		Livestock	(Assam) India (Mazumder, Kalita et al. 2014)
36.	Low level of education	X		Livestock	(Assam) India (Mazumder, Kalita et al. 2014)
37.	Lack of adequate credit availability	X		Livestock	(Assam) India (Mazumder, Kalita et al. 2014)
38.	Shortage of electricity	X		Livestock	(Assam) India (Mazumder, Kalita et al. 2014)
39.	Extension programme for popularizing proven technologies		X	livestock	(Assam) India (Mazumder, Kalita et al. 2014) Eastern DR Congo (Maass, Katunga Musale et al. 2012)
			X	Poultry	Myanmar (Henning, Pym et al. 2007)
40.	Encourage to rear improved breed (cross-breed with local/ indigenous with improved breed) by supplying improved breed		X	Livestock	(Assam) India (Mazumder, Kalita et al. 2014) South Asia, Africa (McDermott, Staal et al. 2010)
			X	Poultry	Myanmar (Henning, Pym et al. 2007)
41.	Encourage to feed balanced nutrients by supplying of feed		X	Livestock	(Assam) India (Mazumder, Kalita et al. 2014) South Asia, Africa (McDermott, Staal et al. 2010)
42.	Providing external credit from financial resources for farmers		X	Livestock	(Assam) India (Mazumder, Kalita et al. 2014)
43.	Strengthening the existing animal health and veterinary service		X	Livestock	(Assam) India (Mazumder, Kalita et al. 2014) South Asia, Africa

No.	Factors affecting livestock production	Constraint	Opportunities	Type of Species	Regions
					(McDermott, Staal et al. 2010)
44.	Enhancing the availability of quality fodder/ Feed type selection		X	Livestock	(Assam) India (Mazumder, Kalita et al. 2014) World (Tarawali, Herrero et al. 2011)
45.	Introduction of forage crops on fallow land, wasteland		X	Livestock	(Assam) India (Mazumder, Kalita et al. 2014)
46.	Promotion and production of low cost feed with locally available ingredients		X	Livestock	(Assam) India (Mazumder, Kalita et al. 2014)
47.	Costs incurred with feeds brought from other states at a high market value		X	Livestock	(Assam) India (Mazumder, Kalita et al. 2014)
48.	Improvement of the power supply system in rural areas		X	Livestock	(Assam) India (Mazumder, Kalita et al. 2014)
49.	Inadequate animal housing and space	X		Livestock	Eastern DR Congo (Maass, Katunga Musale et al. 2012) Sri Lanka (Samarajeewa, Schiere et al. 2003)
50.	Predators	X		Livestock	Eastern DR Congo (Maass, Katunga Musale et al. 2012)
		X		Poultry	Myanmar (Henning, Pym et al. 2007)
51.	Time to search forage	X		Livestock	Eastern DR Congo (Maass, Katunga Musale et al. 2012)
52.	Encouraging livestock as an asset		X	Livestock	Eastern DR Congo (Maass, Katunga Musale et al. 2012)
53.	Food and nutrition – encouraging livestock as consumption		X	Livestock	Eastern DR Congo (Maass, Katunga Musale et al. 2012)
54.	Developing forage reduce the burden of feeding animal for women and children, who mainly took care of animals.		X	Livestock	Eastern DR Congo (Maass, Katunga Musale et al. 2012)
55.	Prospect for forage research		X	Livestock	Eastern DR Congo (Maass, Katunga Musale et al. 2012)

No.	Factors affecting livestock production	Constraint	Opportunities	Type of Species	Regions
56.	Low price of milk	X		Cattle	Malawi (Tebug, Kasulo et al. 2012) Sri Lanka (Samarajeewa, Schiere et al. 2003)
57.	Shortage of water	X		Livestock	Ethiopia (Amenu, Markemann et al. 2013) World (Herrero, Thornton et al. 2009)
58.	Poor quality water	X		Livestock	Ethiopia (Amenu, Markemann et al. 2013)
59.	Low offspring output	X		Livestock	Ethiopia (Amenu, Markemann et al. 2013)
60.	Group housing		X	Small ruminants	Indonesia (IGS Budisatria, HMJ Udo et al. 2007)
61.	Milking goat programme		X	Small ruminants	Indonesia (IGS Budisatria, HMJ Udo et al. 2007)
62.	Animal sharing programme		X	Small ruminants	Indonesia (IGS Budisatria, HMJ Udo et al. 2007)
63.	Slatted floors		X	Small ruminants	Indonesia (IGS Budisatria, HMJ Udo et al. 2007)
64.	Village breeding unit		X	Small ruminants	Indonesia (IGS Budisatria, HMJ Udo et al. 2007)
65.	Extreme weather condition	X		Poultry	Myanmar (Henning, Pym et al. 2007)
				Livestock	World (Hahn, Mader et al. 2003, Herrero, Thornton et al. 2009, Nardone, Ronchi et al. 2010, Nienaber and Hahn 2007)
66.	Vaccination		X	Poultry	Myanmar (Henning, Pym et al. 2007)
			X	Cattle and small ruminants	South Asia, Africa (McDermott, Staal et al. 2010)
67.	Strong domestic demand		X	Cattle and small ruminants	South Asia, Africa (McDermott, Staal et al. 2010)
68.	Potential export		X	Cattle and small ruminants	South Asia, Africa (McDermott, Staal et al. 2010)

No.	Factors affecting livestock production	Constraint	Opportunities	Type of Species	Regions
69.	Regional import substitution		X	Small ruminants	South Asia, Africa (McDermott, Staal et al. 2010)
70.	Low cost family labour		X	Cattle and small ruminants	South Asia (McDermott, Staal et al. 2010)
71.	Presence of crop residues		X	Cattle and small ruminants	South Asia (McDermott, Staal et al. 2010)
72.	Feedlot enterprise		X	Cattle and small ruminants	Africa (McDermott, Staal et al. 2010)
73.	Presence of natural forage		X	Small ruminants	Africa (McDermott, Staal et al. 2010)
74.	Lack of cost-effective way to cross-breed cows	X		Cattle	Africa (McDermott, Staal et al. 2010)
75.	Lack of improved indigenous sires and proven cross breed	X		Cattle	Africa (McDermott, Staal et al. 2010)
76.	Scarcity of feed availability in dry season	X		Cattle and small ruminants	South Asia and Africa (McDermott, Staal et al. 2010) Sri Lanka(Samarajeewa, Schiere et al. 2003)
77.	Use of improved dual (or multi) purpose crops (food-feed)		X	Cattle and small ruminants	World (Tarawali, Herrero et al. 2011)
78.	Trade-offs in use of crop residues for soil quality		X	Cattle and small ruminants	World (Tarawali, Herrero et al. 2011)
79.	Incorporation of feed value parameters into crop breeding and selection programmes		X	Cattle and small ruminants	World (Tarawali, Herrero et al. 2011)
80.	Use of crop genotypes with high quality Residues		X	Cattle and small ruminants	World (Tarawali, Herrero et al. 2011)
81.	Minimize water and nutrient stresses to increase crop yields		X	Cattle and small ruminants	World (Tarawali, Herrero et al. 2011)
82.	Use of manure and traction contributes Positively		X	Cattle and small ruminants	World (Tarawali, Herrero et al. 2011)
83.	Appropriate grazing management to prevent Degradation		X	Cattle and small ruminants	World (Tarawali, Herrero et al. 2011)

No.	Factors affecting livestock production	Constraint	Opportunities	Type of Species	Regions
84.	Location of watering points in Rangelands		X	Cattle and small ruminants	World (Tarawali, Herrero et al. 2011)
85.	Strong institutional arrangements especially for common property		X	Cattle and small ruminants	World (Tarawali, Herrero et al. 2011)
86.	Theft	X		Livestock	Sri Lanka (Samarajeewa, Schiere et al. 2003)
87.	Crop damage	X		Livestock	Sri Lanka (Samarajeewa, Schiere et al. 2003)
88.	High cost of milking animal	X		Cattle	Sri Lanka (Samarajeewa, Schiere et al. 2003)

Annex 4 Summary of research studies that describe factors effecting livestock marketing

No.	Factors affecting on livestock marketing	Constraint	Opportunities	Countries
1.	Inadequate information on available resources	X		Ethiopia, (Hurrissa and Eshetu 2002) South Africa, (Musemwa, Mushunje et al. 2008)
2.	Diseases	X		Ethiopia, (Hurrissa and Eshetu 2002) South Africa, (Musemwa, Mushunje et al. 2008) Asian, African and Pacific nations (Gray, Connell et al. 2012)
3.	Archaic Traditional Production System	X		Ethiopia,(Hurrissa and Eshetu 2002)
4.	Illegal Export Trade	X		Ethiopia,(Hurrissa and Eshetu 2002)
5.	Problems Related to Development Initiatives (Poor management system for high production)	X		Ethiopia,(Hurrissa and Eshetu 2002)
6.	Inadequacy of Infrastructure	X		Ethiopia,(Hurrissa and Eshetu 2002) South Africa (Musemwa, Mushunje et al. 2008) South Asia, Africa (McDermott, Staal et al. 2010)
7.	Absence of Effective Grading System	X		Ethiopia,(Hurrissa and Eshetu 2002) Indonesia (Budisatria, Udo et al. 2008)

No.	Factors affecting on livestock marketing	Constraint	Opportunities	Countries
8.	Absence of Market Information System	X		Ethiopia, (Hurrissa and Eshetu 2002)
9.	Absence of Promotional Activities	X		Ethiopia, (Hurrissa and Eshetu 2002)
10.	Absence of Capable Private Sector	X		Ethiopia, (Hurrissa and Eshetu 2002)
11.	Absence of Quarantine Facilities	X		Ethiopia, (Hurrissa and Eshetu 2002)
12.	Competition	X		Ethiopia, (Hurrissa and Eshetu 2002)
13.	Repeated Bans	X		Ethiopia, (Hurrissa and Eshetu 2002)
14.	Inadequate Port Facilities	X		Ethiopia, (Hurrissa and Eshetu 2002)
15.	Resource assessment		X	Ethiopia ,(Hurrissa and Eshetu 2002)
16.	Disease control		X	Ethiopia, (Hurrissa and Eshetu 2002)
17.	Creating Market Awareness Among Pastorlists		X	Ethiopia, (Hurrissa and Eshetu 2002)
18.	Revitalizing the Private Sector/ Informal market		X	Ethiopia, (Hurrissa and Eshetu 2002) South Africa (Musemwa, Mushunje et al. 2008)
19.	Control of contraband trade		X	Ethiopia, (Hurrissa and Eshetu 2002)
20.	Livestock Breeding Policy		X	Ethiopia, (Hurrissa and Eshetu 2002)
21.	High transactional cost	X		South Africa (Musemwa, Mushunje et al. 2008) South Asia, Africa (McDermott, Staal et al. 2010)
22.	Auctions		X	South Africa (Musemwa, Mushunje et al. 2008)
23.	Butcheries availability		X	South Africa (Musemwa, Mushunje et al. 2008)
24.	Abattoirs availability		X	South Africa (Musemwa, Mushunje et al. 2008)
25.	Poor access to formal output market and inadequate input services		X	South Asia, Africa (McDermott, Staal et al. 2010)

Annex 5 Summary of research studies that describe feedstuffs used in livestock production

No.	Materials used in feeding	Type of livestock	Regions
1.	Cotton stover	Livestock	Zimbabwe (Chawatama, Mutisi et al. 2005)
2.	Sunflowers	Livestock	Zimbabwe (Chawatama, Mutisi et al. 2005)
3.	Blocks	Livestock	Zimbabwe (Chawatama, Mutisi et al. 2005)
4.	Hay	Livestock	Zimbabwe (Chawatama, Mutisi et al. 2005)
5.	Groundnut stover	Livestock	Zimbabwe (Chawatama, Mutisi et al. 2005)
6.	Maize stover	Livestock	Zimbabwe (Chawatama, Mutisi et al. 2005)
7.	Maize grain	Livestock	Zimbabwe (Chawatama, Mutisi et al. 2005)
8.	Commercial feed	Livestock	Zimbabwe (Chawatama, Mutisi et al. 2005)
9.	Maize straw	Livestock	Bhutan, China, India, Indonesia (Budisatria, Udo et al. 2010), Kampuchea, Korea DPR, Korea Rep., Laos, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam (Devendra 1997)
10.	Millet	Livestock	China, India, Myanmar, Nepal, Pakistan (Devendra 1997)
11.	Rice straw	Livestock	Bangladesh, Bhutan, China, India, Indonesia, Japan, Kampuchea, Korea DPR, Korea Rep., Laos, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Thailand, Vietnam (Devendra 1997) Sri Lanka (Devendra 1997, Samarajeewa, Schiere et al. 2003)
12.	Sorghum straw	Livestock	China, India, Korea DPR, Pakistan, Thailand, Vietnam (Devendra 1997)
13.	Wheat straw	Livestock	Bangladesh, China, India, Japan, Korea DPR, Myanmar, Nepal, Pakistan (Devendra 1997)
14.	Oilseed cakes and meals	Livestock	Asia (Devendra 1997)
15.	Cassava leaves	Livestock	Asia (Devendra 1997) Indonesia (Budisatria, Udo et al. 2010)
16.	Coconut cake	Livestock	Asia (Devendra 1997) Sri Lanka (Samarajeewa, Schiere et al. 2003)
17.	Palm kernel cake	Livestock	Asia (Devendra 1997)
18.	Sweet potato vines	Livestock	Asia (Devendra 1997)
19.	Cereal straws	Livestock	Asia (Devendra 1997)
20.	Palm press fibre	Livestock	Asia (Devendra 1997)
21.	Stovers	Livestock	Asia (Devendra 1997)

No.	Materials used in feeding	Type of livestock	Regions
22.	Urea-treated straw	Cattle	China, Thailand (Devendra 1997) Sri Lanka (Samarajeewa, Schiere et al. 2003)
23.	Cotton seedcake	Cattle	China (Devendra 1997)
24.	Sugarcane tops	Cattle	Philippine (Devendra 1997)
25.	Leucaena	Cattle	Thailand, Philippine (Devendra 1997)
26.	Crop residues	Livestock	South Asia (Renard 1977, Thomas, Zerbini et al. 2002) Kenya (Bebe 2003) Africa (McDermott, Staal et al. 2010)
27.	Native grass	Livestock	South Asia (Renard 1977, Thomas, Zerbini et al. 2002)
28.	Weed	Livestock	South Asia (Renard 1977, Thomas, Zerbini et al. 2002) Kenya (Bebe 2003)Africa (McDermott, Staal et al. 2010) Sri Lanka (Samarajeewa, Schiere et al. 2003)
29.	Tree foliage	Livestock	South Asia (Renard 1977, Thomas, Zerbini et al. 2002)
30.	Cultivated forage crop	Livestock	South Asia (Renard 1977, Thomas, Zerbini et al. 2002)
31.	Free range system	Poultry	Eastern DR Congo (Maass, Katunga Musale et al. 2012)
32.	Scavenge	Poultry	Eastern DR Congo (Maass, Katunga Musale et al. 2012)
33.	In the bush	Goat	Eastern DR Congo (Maass, Katunga Musale et al. 2012)
34.	Feed bush along road side	Goat	Eastern DR Congo (Maass, Katunga Musale et al. 2012) Kenya (Bebe 2003)
35.	Forage	Livestock	Eastern DR Congo (Maass, Katunga Musale et al. 2012)
36.	Brewers' grain	Livestock	Eastern DR Congo (Maass, Katunga Musale et al. 2012)
37.	Palm kernel	Livestock	Eastern DR Congo (Maass, Katunga Musale et al. 2012)
38.	Groundnut cake	Livestock	Eastern DR Congo (Maass, Katunga Musale et al. 2012)
39.	Oil mill	Livestock	Eastern DR Congo (Maass, Katunga Musale et al. 2012)
40.	Rice bran	Small ruminants	Indonesia (Budisatria, Udo et al. 2010)Sri Lanka (Samarajeewa, Schiere et al. 2003)
41.	Peeling of crop	Small ruminants	Indonesia (Budisatria, Udo et al. 2010)

No.	Materials used in feeding	Type of livestock	Regions
42.	Elephant grass	Small ruminants	Indonesia (Budisatria, Udo et al. 2010)
43.	Legume leaves	Small ruminants	Indonesia (Budisatria, Udo et al. 2010)
44.	Napier grass/ Grass	Cattle	Kenya (Bebe 2003) Africa (McDermott, Staal et al. 2010) Sri Lanka (Samarajeewa, Schiere et al. 2003)
45.	Banana waste	Livestock	Sri Lanka (Samarajeewa, Schiere et al. 2003)
46.	Creepers	Livestock	Sri Lanka (Samarajeewa, Schiere et al. 2003)
47.	Leaves	Livestock	Sri Lanka (Samarajeewa, Schiere et al. 2003)
48.	Fruit waste	Livestock	Sri Lanka (Samarajeewa, Schiere et al. 2003)
49.	Brachiariamutica	Livestock	Sri Lanka (Samarajeewa, Schiere et al. 2003)
50.	Brachiariabrizantha	Livestock	Sri Lanka (Samarajeewa, Schiere et al. 2003)

Annex 6 Summary of research studies that describe water sources used in livestock production

No.	Source of water	Type of livestock	Regions
1.	River	Livestock	Ethiopia (Amenu, Markemann et al. 2013)
2.	Hand-dug well	Livestock	Ethiopia (Amenu, Markemann et al. 2013)
3.	Borehole	Livestock	Ethiopia (Amenu, Markemann et al. 2013)
4.	Dugout	Livestock	Ethiopia (Amenu, Markemann et al. 2013)
5.	Roadside runoff	Livestock	Ethiopia (Amenu, Markemann et al. 2013)

Annex 7 Summary of research studies that identified risk factors associated with livestock production outcomes

No.	Effect	Cause	Regions
1.	Milk production	Education level	Malawi (Tebug, Kasulo et al. 2012)
		Activity	Malawi (Tebug, Kasulo et al. 2012)
		Experience	Malawi (Tebug, Kasulo et al. 2012)
2.	Herd size	Gender	Malawi (Tebug, Kasulo et al. 2012)
		Grazing system	Malawi (Tebug, Kasulo et al. 2012)
		Experience	Malawi (Tebug, Kasulo et al. 2012)
3.	Small ruminant reared	Poor rural community	Indonesia (IGS Budisatria, HMJ Udo et al. 2007) Kenya (Kristjanson, Krishna et al. 2004, Morand-Fehr and Boyazoglu 1999)
		Family labour	Indonesia (IGS Budisatria, HMJ Udo et al. 2007)
		Time availability	Indonesia (IGS Budisatria, HMJ Udo et al. 2007)

No.	Effect	Cause	Regions
		Capital availability	Indonesia (IGS Budisatria, HMJ Udo et al. 2007)
4.	Price of small ruminants	Moslem feast of sacrifice	Indonesia (Budisatria, Udo et al. 2008)
5.	Reason of selling small ruminants	School fee	Indonesia (Budisatria, Udo et al. 2008)
		Preparation of rice field	Indonesia (Budisatria, Udo et al. 2008)
6.	Drinking water contamination in household	House of small ruminant close to family quarters	Indonesia (I Gede Suparta Budisatria, HMJ Udo et al. 2007)
7.	Improved small ruminant production (Weight)	Supplementary feed (Rice bran)	Indonesia (Budisatria, Udo et al. 2008)
8.	Milk production of cattle	Breed of cattle (Crossbred vs local)	Bhutan (Samdup 1997)
		Grazing system (Free grazing vs semi-grazing vs zero-grazing)	India, Bhutan (Udo, Aklilu et al. 2011)
9.	Reproductive performance	Breed of cattle (Crossbred vs local)	Bhutan (Jong 1996)
10.	Practicing livestock production	Poor rural community 80% in Africa 40% in India 66% in Bangladesh	Africa, India, Bangladesh (UN FAO 2009) Indonesia (IGS Budisatria, HMJ Udo et al. 2007) Kenya (Kristjanson, Krishna et al. 2004, Morand-Fehr and Boyazoglu 1999)
11.	Likelihood/ Income of farmers	Agro-pastoral and pastoral systems	World (McDermott, Staal et al. 2010)
		Extensive mixed crop–livestock systems	World (McDermott, Staal et al. 2010)
		Intensive mixed crop–livestock systems	World (McDermott, Staal et al. 2010)
		Industrial systems	World (McDermott, Staal et al. 2010)
		Crop-animal production 50-80% of total income	East Asia, (Deshingkar, Farrington et al. 2008, McDermott, Staal et al. 2010) South East Asia, Africa (Nzuma and Baltenweck 2008)
		Cattle production	Zambia, Kenya, Sri Lanka (Moll, Staal et al. 2007)
12.	Extensive mixed crop–livestock systems	Rain-fed agriculture	World (McDermott, Staal et al. 2010)
		Medium population density	World (McDermott, Staal et al. 2010)

No.	Effect	Cause	Regions
		Moderate agro-ecological potential	World (McDermott, Staal et al. 2010)
		Weak linkage to market	World (McDermott, Staal et al. 2010)
13.	Intensive mixed crop–livestock systems	High population density	World (McDermott, Staal et al. 2010)
		Irrigation	World (McDermott, Staal et al. 2010)
		High agro-ecological potential	World (McDermott, Staal et al. 2010)
		Good linkage to market	World (McDermott, Staal et al. 2010)
14.	Industrial system	Controlled feed intake	World (McDermott, Staal et al. 2010)
		Genetic control	World (McDermott, Staal et al. 2010)
		Health inputs	World (McDermott, Staal et al. 2010)
15.	Agriculture transforming	Livestock product quantity demand	World (Tarawali, Herrero et al. 2011)
16.	Quantity demand for livestock products in rural	Small holder competition	World (Tarawali, Herrero et al. 2011)
		Informal markets	World (Tarawali, Herrero et al. 2011)
		Ranging from increased participation in formal markets	World (Tarawali, Herrero et al. 2011)
		Transition to larger farms	World (Tarawali, Herrero et al. 2011)
		Some leaving the sector entirely	World (Tarawali, Herrero et al. 2011)
		Increased efficiency of production and greater market linkage important	World (Tarawali, Herrero et al. 2011)
17.	Quality demand for livestock products	Complex value chains	World (Tarawali, Herrero et al. 2011)
		Vertical coordination	World (Tarawali, Herrero et al. 2011)
		Small role for small scale entrepreneurs	World (Tarawali, Herrero et al. 2011)
		Smallholders rarely competitive unless where labour and inputs benefit	World (Tarawali, Herrero et al. 2011)

No.	Effect	Cause	Regions
18.	Purpose of livestock production	Amount of landowning	Sri Lanka (Samarajeewa, Schiere et al. 2003)
19.	Live weight gain	Place of feed resources	Sri Lanka (Samarajeewa, Schiere et al. 2003)

Annex 8 Questionnaire for Farmer Survey

Township Survey on Observation of the Animal Production, Animal Health Care System, Trade and Marketing Network in the Central Dry Zone (CDZ) of Myanmar

Survey Objectives

- To observe and describe the traditional animal production system and current animal health care system currently practised in the Central Dry Zone (CDZ) of Myanmar.
- To observe and describe farmer's attitude and awareness on animal diseases and major cross-species disease transmission in accordance with the one-health paradigm.
- To observe and describe the animal trade and marketing network in the Central Dry Zone of Myanmar
- To find out the most efficient, reliable and relevant solutions for the development of livestock production and one-health paradigm in the Central Dry Zone of Myanmar by analysing the observations from this survey

Declaration

According to the reports, it is found out that the livestock population is very high in the central part of Myanmar than other regions. Due to the reason of getting little rain in the central part of Myanmar, the central part of Myanmar become named as "Central Dry Zone of Myanmar", and people, who live in these areas, cannot rely on agriculture and crop production. As a consequence, the animal production become playing a critical role in the Central Dry Zone. Even though the animal production is popular in these areas, the farmers, practicing the animal production in these areas, have still faced with some dilemmas in their animal production such as animal management, animal diseases and trade. The information collected from the farmer will be confidential. The survey is conducted with the purpose of finding out the current animal production system, animal health problem in order to ensure that recommendation for production is useful for famers; and trade and marketing network in the Central Dry Zone of Myanmar, as part of my PhD study.

QUESTIONNAIRE FOR LIVESTOCK FARMERS

General information

Date (DD/MM/YY) ______________________________

Name of interviewer ______________________________

Location

GPS point ______________________ P-code ______________________

Region ______________________

District ______________________

Township ______________________

Village tract ______________________

Village ______________________

Number of household ______________________

General Information of the Interviewee (Please tick √ the appropriate box)

Name - ______________________ Age - ( ) years old

Gender - Male ( ) Female ( )

Role of the interviewee in the household - (---)

Which of the following animal production do you have experience in?

(Please tick √ the appropriate box)

Species	No experience	<5 years	5-10 years	>10 years
Cattle				
Sheep				
Goat				
Village chickens				

Which of the following animal production do you rear today?

(Please tick √ the appropriate box)

Species	Rearing today
Cattle	
Sheep	
Goat	
Village chickens	
Other (Describe______________________________)	

Household details

Number of family member (Permanent residents) __________ people

Number of family member involving in animal production __________ people

Do you hire labour for animal production? Yes ☐ No ☐

Attitude and Practice of Farmers on Disease Prevention and Control

Impact of Animal Production on Human Health

Which species of animal do you think can transmit zoonotic disease to human?

Cattle ( )

Sheep ( )

Goat ( )

Chickens ( )

Dog ( )

Pig ( )

Others (Describe____)

Which level do you consider the impacts of the risk of transmissible diseases from animal to human on human health?

Type of livestock species	Very high	High	Moderate	Low	Very low
Cattle					
Sheep and goat					
Village chickens					

How can you prevent the disease transmission from these animal to you and your family?

Type of livestock species	Please specify
Cattle	--
Sheep and goat	--
Village chickens	--

What are the main barriers to prevent the disease transmission from these animals to you and your family?

Type of livestock species	Please specify
Cattle	--
Sheep and goat	--
Village chickens	--

From where do you able to get the information about the information to prevent the disease transmission from these animal to you and your family?

Type of livestock species	Please specify
Cattle	--
Sheep and goat	--
Village chickens	--

Are you confident that you can prevent the transmissible animal disease to human being transmitted from these animal to you and your family?

Type of livestock species	Not known	Yes	No
Cattle			
Sheep and goat			
Village chickens			

Impact of FMD in ruminants and ND in chicken on the trade and marketing

Do you know the diseases described below?

Type of animal production	Name of Disease	Yes	No
Cattle production	FMD		
Sheep and goat production	FMD		
Village chicken production	ND		

If animal production is important, what kind of animal do you think you can get more profit?

- [ ] Cattle production
- [ ] Sheep production
- [ ] Goat production
- [ ] Chicken production
- [ ] Others (Describe ____)

Do you think the incidence of the following disease in your farm animals can cause loss in marketing and trading?

Type of animal production	Name of Disease	Don't know	Yes	No
Cattle production	FMD			
Sheep and goat production	FMD			
Village chicken production	ND			

Do you think the vaccination can prevent the following disease occurrence?

Type of animal production	Type of vaccine	Not known	Yes	No
Cattle production	FMD			
Sheep and goat production	FMD			
Village chicken production	ND			

If not, what prevention methods are efficient in FMD prevention?

Type of animal production	Please specify
Cattle production	-- --
Sheep and goat production	-- --
Village chicken production	-- --

Would you like to practice the following vaccination according to your animal species in your farm?

Type of animal production	Type of vaccine	Not known	Yes	No
Cattle production	FMD			
Sheep and goat production	FMD			
Village chicken production	ND			

In practicing vaccination, what are the main barriers or obstacles to follow vaccination programme?

Type of animal production	Vaccine	Barrier (Please specify)
Cattle production	FMD	
Sheep and goat production	FMD	
Village chicken production	ND	

Where do you get some guidance or instructions about vaccination programme?

Type of animal production	Vaccine	Township vet office	Private vet	Blue cross worker	Middle man	Traders	Village headman	Others
Cattle production	FMD							
Sheep and goat production	FMD							
Village chicken production	ND							

Are you confident that the vaccination will be effective?

Type of animal production	Type of vaccine	Not known	Yes	No
Cattle production	FMD			
Sheep and goat production	FMD			
Village chicken production	ND			

Cattle Husbandry Practice

Type and Number of Animal

What kind of animal do you have in your farm? Please write down the number of each kind of animal owned by the household today and 12 months ago.

Time	**Type of animal**									
Today	Male calves:		Female calves:		Cows:		Bulls:		Castrated males:	
12 months ago	Male calves:		Female calves:		Cows:		Bulls:		Castrated males:	

Definition: Calves ≤ 12 months old; Cows > 12 months old (Female); Bull > 12 months old (Male)

What age do you usually castrate your animal	< 6 m.o	☐	6-12 m.o	☐	> 12m.o	☐	Do not castrate	☐

(Please tick √ the appropriate box)

Housing

(Please tick √ the appropriate box)

Do you provide shelter for your animals? Yes ☐ No ☐

Please provide the specific information and materials used for the shelter. (Please tick √ the appropriate box)

Roof				**Wall**				**Floor**			
None	Corrugate	Leave	Others	None	Bamboo	Wood	Others	None	Wood	Bamboo	Other

Where do you provide their housing?

Underneath the house	☐	Extension of the house	☐	Separate building in the farm	☐	Away from the farm	☐	Other (describe: ______________)	☐

Feeding system

Indicate the importance of different kinds of feeding to the classes of cattle in your household by writing numbers in the table.
(Please write 1= a small amount or no feeding; 2= Moderate amount of the diet; 3= Most of all of the diet in the appropriate box)

Season	Free grazing	Supplementary feedstuff							Class of animal
		Cut & carried Grass	Rice straw	Crop residues	Groundnut cake	Sesame cake	Sorghum	Other (Describe: ______________)	
Summer									All
									Bull & draught
									Cow
									Calf
Rainy									All
									Bull & draught
									Cow
									Calf
Winter									All
									Bull & draught
									Cow
									Calf

What is the average total hours grazed per day? ____________________ hours

How many times are animals usually grazed each day? ____________________ times

What is the gender and age of the person(s) who does most supervision of free-grazing animals?

____

Water supply

What is the source of water provided at home? (Please tick √ the appropriate boxes)

River	Well	Pond	Tap water	Others (describe ___________)	Do not provide water at home

How often do you usually provide water for your animals at home? (Please tick √ the appropriate boxes)

Season	Type of animal	Daily	Several times per week	Once a week	Other (Describe)
Summer	Bull & draught				
	Cow				
	Calf				
Rainy	Bull & draught				
	Cow				
	Calf				
Winter	Bull & draught				
	Cow				
	Calf				

Weaning Management

At what age do you usually wean your calves?

≤ 3 m.o		4-6 m.o		6-12 m.o		> 12 m.o		Do not wean	

Breeding Management

Please specify the purpose of breeding.

To sell to others		Replacement animal for my own herd		Male- To hire for breeding		Other (Describe: ___________)		Do not breed	

If you breed, what is the source(s) do you use? Please tick √ the appropriate box(es)

Natural mating	
Own bull	
Another bull in village	
Bull from other village	
Other (Describe) ______________________	

Artificial insemination	
Township vet office	
Blue Cross Worker	
Private vet	
Other (Describe) ______________________	

Purpose of rearing and the role of importance in family's income

Please describe the purpose and the role of importance in your family's income. Please tick √ the appropriate box(es)

Meat		**Milk**		**Draught power**		**Breeding**		**Others (Please fill the reasons)**	
Very important		Very important		Very important		Very important		Very important	
Important		Important		Important		Important		Important	
Not too important		Not too important		Not too important		Not too important		Not too important	

Definition: Very important = Get more than 50% of the total income of a typical year; Important = Get more than 10-50% of the total income of a typical year; Not too important = Get less than 10% of the total income of a typical year

Cause of animal loss			Bull/draught			Cow			Calves (< 6 months)		
No.	**Description**	**Clinical signs seen with the past two years**	**Frequency***	**Number affected**	**Severity**	**Frequency***	**Number affected**	**Severity**	**Frequency***	**Number affected**	**Severity**
1.	Physical Problem	Sore or abnormal hoof, foot or leg causing abnormal movement									
		Animal not growing as much as other animals from the household									
		Weakness, or frequently lying or sitting down									
2.	Respiratory Problem	Coughing, sneezing, discharge from the nose or other breathing problems									
3.	Digestive problems	Drooling or sores in the mouth									
		Unwillingness to eat or anorexia									
		Constipation or straining to defecate, or pain in the belly									
		Diarrhoea									
4.	Nervous System Problem	Examples: Blindness, circling, abnormal behaviour									
5.	Skin Problem	Itchiness/scratching									
		Loss of hair/wool, abnormal colour or appearance of skin, such as scabs on surface									

Cause of animal loss			Bull/draught			Cow			Calves (< 6 months)		
No.	**Description**	**Clinical signs seen with the past two years**	**Frequency***	**Number affected**	**Severity**	**Frequency***	**Number affected**	**Severity**	**Frequency***	**Number affected**	**Severity**
		Swelling or other problem with udder									
6.	Reproductive Problem	Abortions, Offspring born dead, discharge from vulva									
		Unable to mate or abnormal mating behaviour									
7.	Urinary System Problem	Difficulty / straining to urinate, abnormal urine colour									
8.	Sudden death	Found dead									
9.	Other Problems	Others (---)									
10.	Bad weather										
11.	Predators										
12.	Theft										

* Frequency: 0= Never; 1= Rarely; 2= Moderately frequently; 3= Very frequently or all the time
**Severity: 1= Not severe and recover; 2 = Severe but not death (recover); 3= Death

Treatment

What type of medical treatment you provide when your animal is sick?

	Traditional medicine
	Commercial medicine
	None

Who provides advice about managing health or treating illness of your cattle?

Person who give advices	Never	Very often	Often	Sometimes	Rarely
Veterinarians					
Middleman					
Neighbours					
Other farmers					
Relatives					
Yourself					
Blue Cross Worker					
Others (Describe________________________________)					

Who actually gives treatments or medicines to your cattle?

Person who give treatment	Never	Very often	Often	Sometimes	Rarely
Veterinarians					
Middleman					
Neighbours					
Other farmers					
Relatives					
Yourself					
Blue Cross Worker					
Others (Describe ______________)					

Animal Disease Prevention and Control

Do you practice vaccination? Yes ( ) No ( )

Do you know what type of vaccine you used? Yes ( ) No ( )

If yes, please specify: ____

How often do you practice vaccination for your animal?

Once a year	Twice a year	Three times a year	More than three times a year	Remarks

Who administer the vaccine to your animal?

Middleman	Blue cross worker	Vet	Relatives	Yourself	Others (Describe)

Biosecurity and Disinfection

70. If there is sick animal in your village, how do you usually prevent the disease transmission?

- [ ] Minimizing the contact of other animal to sick animal
- [ ] Quarantine the sick animal
- [ ] Reducing the entry of other people or visitors into the farm
- [ ] Disinfection the farm
- [ ] Others (Describe :____)

Which of the following do you usually do on your farm to help manage the health of your cattle?

☐	Removal of feces	☐	Sweeping	☐	Cleansing with water	☐	Disinfection	☐	Other (Describe___ ___________)

Segregation

Do you usually segregate the sick animal? Yes ( ) No ( )

Do you usually segregate the sick animal until it recovers? Yes ( ) No ( )

If yes, when it recover, what do you do with it?

- [ ] Sell the animal
- [ ] Keep using for farm work
- [ ] Keep the animal together with other animals again
- [ ] Send it to other village (-----------------)
- [ ] Send it relatives' house (-----------------)
- [ ] Others ---------------------------------
- [ ] Do nothing

<u>Trade and Marketing Network</u> (Please tick √ the appropriate box)

Usual Age and Purpose of Purchase?

Species	Young Animal				Adult Female				Adult Male				Others	
	Draught power	**Meat**	**Breeding**	**Others**	**Draught power**	**Meat**	**Breeding**	**Others**	**Draught power**	**Meat**	**Breeding**	**Others**	**Milk**	**Egg**
Cattle														

What is this question? Specify time period over which typical prices are described

Type of animal	Purpose														
	Meat			**Draught power**			**Breeding**			**Milk**			**Others describe**		
	Sum	**Rny**	**Wint**	**Sum**	**Rny**	**Wint**	**Sum**	**Rny**	**Wint**	**Sum**	**Rny**	**Wint**	**Sum**	**Rny**	**Wint**
Calve															
Cow															
Bull															

Information on Sale and Purchase of the Animals

Cattle Production

Please list the name of people you directly sell or buy cattle to or from within the two years (Please yourself as person No.1)

No.	Name	Type of career	Address	Phone number	For sale	For purchase
1		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others ------------------------ ☐ Main purpose ☐ Only for sale ☐ Only for purchase ☐ Both			☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (------- ------------------------ ------------------------ -----------------------)	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (------- ------------------------ ------------------------ -----------------------)
2		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others ------------------------ ☐ Main purpose ☐ Only for sale ☐ Only for purchase ☐ Both			☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (------- ------------------------ ------------------------ -----------------------)	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (------- ------------------------ ------------------------ -----------------------)
3		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer			☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house

No.	Name	Type of career	Address	Phone number	For sale	For purchase
		☐ Slaughter house ☐ Others ------------------------ ☐ Main purpose ☐ Only for sale ☐ Only for purchase ☐ Both			☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (---)	☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (---)
4		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others ------------------------ ☐ Main purpose ☐ Only for sale ☐ Only for purchase ☐ Both			☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (---)	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (---)
5		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others ------------------------ ☐ Main purpose ☐ Only for sale ☐ Only for purchase ☐ Both			☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (---)	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (---)

Please describe how often do you usually to your farm for animal sale and purchase within 24 months?

Identification of person	Type of work	How many times per year	Total Number of animal sale or purchase		
			Bull	Cow	Calve
Person No.1	Sale				
	Purchase				
Person No.2	Sale				
	Purchase				
Person No.3	Sale				
	Purchase				
Person No.4	Sale				
	Purchase				
Person No.5	Sale				
	Purchase				

Sheep and Goat Husbandry Practice

Type and Number of Animal

What kind of animal do you have in your farm? Please write down the number of each kind of animal owned by the household today and 12 months ago.

Time	**Type of animal**									
Today	Male offspring:		Female offspring:		Adult female:		Adult male:		Castrated males:	
12 months ago	Male offspring:		Female offspring:		Adult female:		Adult male:		Castrated males:	

Definition: Lamb/Kid≤ 12 months old; Ewe/Dam > 12 months old (Female); Ram/Buck > 12 months old (Male)

What age do you usually castrate your animal? < 6 m.o ☐ 6-12 m.o ☐ > 12m.o ☐ Do not castrate ☐

Housing (Please tick √ the appropriate box)

Do you provide shelter for your animals? Yes ☐ No ☐

Please provide the specific information and materials used for the shelter. (Please tick √ the appropriate box)

Roof				**Wall**				**Floor**			
None	Corrugate	Leave	Others	None	Bamboo	Wood	Others	None	Wood	Bamboo	Other

Where do you provide their housing?

Underneath the house ☐ Extension of the house ☐ Separate building in the farm ☐ Away from the farm ☐ Other (describe: _____________) ☐

Feeding system

Indicate the importance of different kinds of feeding to the classes of small ruminant in your household by writing numbers in the table.

(Please write 1= a small amount or no feeding; 2= Moderate amount of the diet; 3= Most of all of the diet in the appropriate box)

Season	**Free grazing**	**Supplementary feedstuff**							**Class of animal**
		Cut & carried Grass	**Rice straw**	**Crop residues**	**Groundnut cake**	**Sesame cake**	**Sorghum**	**Other (Describe: _______________)**	
Summer									All
									Adult male
									Adult female
									Offspring
Rainy									All
									Adult male
									Adult female
									Offspring
Winter									All
									Adult male
									Adult female
									Offspring

What is the average total hours grazed per day? ______________________ hours

How many times are animals usually grazed each day? ______________________ times

What is the gender and age of the person(s) who does most supervision of free-grazing animals?

____

Water supply

What is the source of water provided at home? (Please tick √ the appropriate boxes)

River	Well	Pond	Tap water	Others (describe ___________)	Do not provide water at home

How often do you usually provide water for your animals at home? (Please tick √ the appropriate boxes)

Season	Type of animal	Daily	Several times per week	Once a week	Other (Describe)
Summer	Adult male				
	Adult female				
	Offspring				
Rainy	Adult male				
	Adult female				
	Offspring				
Winter	Adult male				
	Adult female				
	Offspring				

Weaning Management

At what age do you usually wean your offspring?

≤ 3 m.o ☐ 4-6 m.o ☐ 6-12 m.o ☐ > 12 m.o ☐ Do not wean ☐

Breeding Management

Please specify the purpose of breeding.

To sell to others ☐ Replacement animal for my own herd ☐ Male- To hire for breeding ☐ Other (Describe: ___________) ☐ Do not breed ☐

If you breed, what is the source(s) do you use? Please tick √ the appropriate box(es)

Natural mating	
Own male	
Another male in village	
Male from other village	
Other (Describe) ____________________	

Artificial insemination	
Township vet office	
Blue Cross Worker	
Private vet	
Other (Describe) ____________________	

<u>Purpose of rearing and the role of importance in family's income</u>

Please describe the purpose and the role of importance in your family's income. Please tick √ the appropriate box(es)

Meat		**Milk**		**Draught power**		**Breeding**		**Others (Please fill the reasons)**	
Very important		Very important		Very important		Very important		Very important	
Important		Important		Important		Important		Important	
Not too important		Not too important		Not too important		Not too important		Not too important	

Definition: Very important = Get more than 50% of the total income of a typical year; Important = Get more than 10-50% of the total income of a typical year; Not too important = Get less than 10% of the total income of a typical year

Cause of animal loss			Adult male			Adult female			Offspring		
No.	**Description**	**Clinical signs seen with the past two years**	**Frequency***	**Number affected**	**Severity**	**Frequency***	**Number affected**	**Severity**	**Frequency***	**Number affected**	**Severity**
1.	Physical Problem	Sore or abnormal hoof, foot or leg causing abnormal movement									
		Animal not growing as much as other animals from the household									
		Weakness, or frequently lying or sitting down									
2.	Respiratory Problem	Coughing, sneezing, discharge from the nose or other breathing problems									
3.	Digestive problems	Drooling or sores in the mouth									
		Unwillingness to eat or anorexia									
		Constipation or straining to defecate, or pain in the belly									
		Diarrhoea									
4.	Nervous System Problem	Examples: Blindness, circling, abnormal behaviour									
5.	Skin Problem	Itchiness/scratching									
		Loss of hair/wool, abnormal colour or appearance of skin, such as scabs on surface									

Cause of animal loss			Adult male			Adult female			Offspring		
No.	**Description**	**Clinical signs seen with the past two years**	**Frequency***	**Number affected**	**Severity**	**Frequency***	**Number affected**	**Severity**	**Frequency***	**Number affected**	**Severity**
		Swelling or other problem with udder									
6.	Reproductive Problem	Abortions, Offspring born dead, discharge from vulva									
		Unable to mate or abnormal mating behaviour									
7.	Urinary System Problem	Difficulty / straining to urinate, abnormal urine colour									
8.	Sudden death	Found dead									
9.	Other Problems	Others (--)									
10.	Bad weather										
11.	Predators										
12.	Theft										

* Frequency: 0= Never; 1= Rarely; 2= Moderately frequently; 3= Very frequently or all the time
**Severity: 1= Not severe and recover; 2 = Severe but not death (recover); 3= Death

Treatment

What type of medical treatment you provide when your animal is sick?

☐	Traditional medicine
☐	Commercial medicine
☐	None

Who provides advice about managing health or treating illness of your cattle?

Person who give advices	Never	Very often	Often	Sometimes	Rarely
Veterinarians					
Middleman					
Neighbours					
Other farmers					
Relatives					
Yourself					
Blue Cross Worker					
Others (Describe________________________________)					

Who actually gives treatments or medicines to your small ruminants?

Person who give treatment	Never	Very often	Often	Sometimes	Rarely
Veterinarians					
Middleman					
Neighbours					
Other farmers					
Relatives					
Yourself					
Blue Cross Worker					
Others (Describe ______________)					

Animal Disease Prevention and Control

Do you practice vaccination? Yes ( ) No ( )

Do you know what type of vaccine you used? Yes ( ) No ( )

If yes, please specify: ____

How often do you practice vaccination for your animal?

Once a year	Twice a year	Three times a year	More than three times a year	Remarks

Who administer the vaccine to your animal?

Middleman	Blue cross worker	Vet	Relatives	Yourself	Others (Describe)

Biosecurity and Disinfection

If there is sick animal in your village, how do you usually prevent the disease transmission?

- ☐ Minimizing the contact of other animal to sick animal
- ☐ Quarantine the sick animal
- ☐ Reducing the entry of other people or visitors into the farm
- ☐ Disinfection the farm
- ☐ Others (Describe :____)

Which of the following do you usually do on your farm to help manage the health of your cattle?

	Removal of feces		Sweeping		Cleansing with water		Disinfection		Other (Describe___ ___________)

Segregation

Do you usually segregate the sick animal? Yes ( ) No ( )

Do you usually segregate the sick animal until it recovers? Yes ( ) No ( )

If yes, when it recover, what do you do with it?

	Sell the animal
	Keep using for farm work
	Keep the animal together with other animals again
	Send it to other village (-----------------)
	Send it relatives' house (-----------------)
	Others ----------------------------------
	Do nothing

<u>Trade and Marketing Network</u> (Please tick √ the appropriate box)

Usual Age and Purpose of Purchase Need to distinguish males from females???

Species	Young Animal				Adult Female				Adult Male				Others	
	Draught power	Meat	Breeding	Others	Draught power	Meat	Breeding	Others	Draught power	Meat	Breeding	Others	Milk	Egg
Sheep														
Goat														

What is this question? Specify time period over which typical prices are described

Type of animal	Purpose											
	Meat			Breeding			Milk			Others describe		
	Sum	Rny	Wint	Sum	Rny	Wint	Sum	Rny	Wint	Sum	Rny	Wint
Kid												
Dam												
Buck												
Lamb												
Ewe												
Ram												

Information on Sale and Purchase of the Animals

Please list the name of people you directly sell or buy cattle to or from within the two years (Please yourself as person No.1)

No.	Name	Type of career	Address	Phone number	For sale	For purchase
1		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others ------------- ☐ Main purpose ☐ Only for sale ☐ Only for purchase ☐ Both			☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (---)	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (---)
2		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others ------------- ☐ Main purpose ☐ Only for sale ☐ Only for purchase ☐ Both			☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (---)	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (---)
3		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house			☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house

No.	Name	Type of career	Address	Phone number	For sale	For purchase
		□ Others ------------- □ Main purpose □ Only for sale □ Only for purchase □ Both			□ Village headman house □ Grazing ground □ Other village (---)	□ Village headman house □ Grazing ground □ Other village (---)
4		□ Middle man □ Trader □ Neighbours □ Other farmer □ Slaughter house □ Others ------------- □ Main purpose □ Only for sale □ Only for purchase □ Both			□ Your own house □ Cattle market □ Live market □ Slaughter house □ Middleman/Trader house □ Village headman house □ Grazing ground □ Other village (---)	□ Your own house □ Cattle market □ Live market □ Slaughter house □ Middleman/Trader house □ Village headman house □ Grazing ground □ Other village (---)
5		□ Middle man □ Trader □ Neighbours □ Other farmer □ Slaughter house □ Others ------------- □ Main purpose □ Only for sale □ Only for purchase □ Both			□ Your own house □ Cattle market □ Live market □ Slaughter house □ Middleman/Trader house □ Village headman house □ Grazing ground □ Other village (---)	□ Your own house □ Cattle market □ Live market □ Slaughter house □ Middleman/Trader house □ Village headman house □ Grazing ground □ Other village (---)

Please describe how often do you usually to your farm for animal sale and purchase within 24 months?

Identification of person	**Type of work**	**How many times per year**	**Total Number of animal sale or purchase**		
			Offspring	**Adult female**	**Adult male**
Person No.1	Sale				
	Purchase				
Person No.2	Sale				
	Purchase				
Person No.3	Sale				
	Purchase				
Person No.4	Sale				
	Purchase				
Person No.5	Sale				
	Purchase				

Village Chicken Husbandry Practice

Animal Production System

Type and Number of Animal

What kind of animal do you have in your farm? Please write down the number of each kind of animal owned by the household today and 12 months ago.

Time	Type of animal					
Today	Chick		Hen		Cock	
12 months ago	Chick		Hen		Cock	
Definition:	Chick ≤ 22 months old; Hen >2 months old (Female); Cock >2 months old (Male)					

Housing (Please tick √ the appropriate box)

Do you provide shelter for your animals? Yes ☐ No ☐

Where do you provide their housing?

Underneath the house	☐	Extension of the house	☐	Separate building in the farm	☐	Bamboo coop	☐	On the tree	☐	Other (describe: ______________)	☐

Feeding system

Indicate the importance of different kinds of feeding to the classes of cattle in your household by writing numbers in the table.

(Please write 1= a small amount or no feeding; 2= Moderate amount of the diet; 3= Most of all of the diet in the appropriate box)

Season	Free grazing	Supplementary feedstuff						Class of animal
		Good quality rice	Broken rice	Rice bran	Broken pea	Household scrap	Others (Describe ______________)	
Summer								All
								Cock
								Hen
								Chick
Rainy								All
								Cock
								Hen
								Chick
Winter								All
								Cock
								Hen
								Chick

Water supply

What is the source of water provided at home? (Please tick √ the appropriate boxes)

River	Well	Pond	Tap water	Others (describe ___________)	Do not provide water at home

How often do you usually provide water for your animals at home? (Please tick √ the appropriate boxes)

Season	Type of animal	Daily	Several times per week	Once a week	Other (Describe)
Summer	Cock				
	Hen				
	Chick				
Rainy	Cock				
	Hen				
	Chick				
Winter	Cock				
	Hen				
	Chick				

Purpose of rearing and the role of importance in family's income

Please describe the purpose and the role of importance in your family's income. Please tick √ the appropriate box(es)

Meat		Egg		Breeding		Others (Please fill the reasons)	
Very important		Very important		Very important		Very important	
Important		Important		Important		Important	
Not too important		Not too important		Not too important		Not too important	

Definition:
Very important = Get more than 50% of the total income of a typical year
Important = Get more than 10-50% of the total income of a typical year
Not too important = Get less than 10% of the total income of a typical year

Cause of animal loss			Cock			Hen			Chick		
No.	**Description**	**Clinical signs seen with the past two years**	**Frequency***	**Number affected**	**Severity**	**Frequency***	**Number affected**	**Severity**	**Frequency***	**Number affected**	**Severity**
1.	Physical Problem	Twisted head and neck									
		Animal not growing as much as other animals from the household									
		Weakness, or frequently lying or sitting down									
2.	Respiratory Problem	Coughing, sneezing, discharge from the nose or other breathing problems									
3.	Digestive problems	Unwillingness to eat or anorexia; Constipation or straining to defecate; or pain in the belly									
		Diarrhoea									
4.	Nervous System Problem	Examples: Blindness, circling, abnormal behaviour									
5.	Skin Problem	Itchiness/scratching									
		Loss of feather, abnormal colour or appearance of skin, such as scabs on surface									
		Swelling or other problem with udder									
6.	Reproductive Problem	Poor egg quality; Abnormal shape of egg; Soften egg shell									
		Decreased egg production									
7.	Sudden death	Found dead									
8.	Other Problems	Others (--------------------------------------- -- -- -- --)									

Cause of animal loss			Cock			Hen			Chick		
No.	**Description**	**Clinical signs seen with the past two years**	**Frequency***	**Number affected**	**Severity**	**Frequency***	**Number affected**	**Severity**	**Frequency***	**Number affected**	**Severity**
		--- --- --- ---------)									
9.	Bad weather										
10.	Predators										
11.	Theft										

* Frequency: 0= Never; 1= Rarely; 2= Moderately frequently; 3= Very frequently or all the time
**Severity: 1= Not severe and recover; 2 = Severe but not death (recover); 3= Death

Treatment

What type of medical treatment you provide when your animal is sick?

- [ ] Traditional medicine
- [ ] Commercial medicine
- [ ] None

Who provides advice about managing health or treating illness of your chickens?

Person who give advices	Never	Very often	Often	Sometimes	Rarely
Veterinarians					
Middleman					
Neighbours					
Other farmers					
Relatives					
Yourself					
Blue Cross Worker					
Others (Describe________________________________)					

Who actually gives treatments or medicines to your chickens?

Person who give treatment	Never	Very often	Often	Sometimes	Rarely
Veterinarians					
Middleman					
Neighbours					
Other farmers					
Relatives					
Yourself					
Blue Cross Worker					
Others (Describe ______________)					

Animal Disease Prevention and Control

Do you practice vaccination? Yes ( ) No ( )

Do you know what type of vaccine you used? Yes ( ) No ( )

If yes, please specify: ____

How often do you practice vaccination for your animal?

Once a year	Twice a year	Three times a year	More than three times a year	Remarks

Who administer the vaccine to your animal?

Middleman	Blue cross worker	Vet	Relatives	Yourself	Others (Describe)

Biosecurity and Disinfection

If there is sick animal in your village, how do you usually prevent the disease transmission?

- [ ] Minimizing the contact of other animal to sick animal
- [ ] Quarantine the sick animal
- [ ] Reducing the entry of other people or visitors into the farm
- [ ] Disinfection the farm
- [ ] Others (Describe:____)

Which of the following do you usually do on your farm to help manage the health of your cattle?

☐	Removal of feces	☐	Sweeping	☐	Cleansing with water	☐	Disinfection	☐	Other (Describe___ ___________)

Segregation

Do you usually segregate the sick animal? Yes (   ) No (   )

Do you usually segregate the sick animal until it recovers? Yes (   ) No (   )

If yes, when it recover, what do you do with it?

- ☐ Sell the animal
- ☐ Keep using for farm work
- ☐ Keep the animal together with other animals again
- ☐ Send it to other village (-----------------)
- ☐ Send it relatives' house (-----------------)
- ☐ Others ----------------------------------
- ☐ Do nothing

<u>Trade and Marketing Network</u> (Please tick √ the appropriate box)

Usual Age and Purpose of Purchase Need to distinguish males from females???

Species	Chick				Hen				Cock				Others	
	Draught power	Meat	Breeding	Others	Draught power	Meat	Breeding	Others	Draught power	Meat	Breeding	Others	Milk	Egg
Village chickens														

What is this question? Specify time period over which typical prices are described

Type of animal	Purpose											
	Meat			Breeding			Egg			Others describe		
	Sum	Rny	Wint	Sum	Rny	Wint	Sum	Rny	Wint	Sum	Rny	Wint
Chick												
Hen												
Cock												

Information on Sale and Purchase of the Animals

Please list the name of people you directly sell or buy cattle to or from within the two years (Please yourself as person No.1)

No.	Name	Type of career	Address	Phone number	For sale	For purchase
1		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others ------------- ☐ Main purpose ☐ Only for sale ☐ Only for purchase ☐ Both			☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (-------- ------------------------ -----------------------)	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (-------- ------------------------ -----------------------)
2		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others ------------- ☐ Main purpose ☐ Only for sale			☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (-------- ------------------------ -----------------------)	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (-------- ------------------------ -----------------------)

No.	Name	Type of career	Address	Phone number	For sale	For purchase
		☐ Only for purchase ☐ Both				
3		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others ------------- ☐ Main purpose ☐ Only for sale ☐ Only for purchase ☐ Both			☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (---)	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (---)
4		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others ------------- ☐ Main purpose ☐ Only for sale			☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (---)	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (---)

No.	Name	Type of career	Address	Phone number	For sale	For purchase
		☐ Only for purchase ☐ Both				
5		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others ------------- ☐ Main purpose ☐ Only for sale ☐ Only for purchase ☐ Both			☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (---)	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (---)

Please describe how often do you usually to your farm for animal sale and purchase within 24 months?

Identification of person	Type of work	How many times per year	Total Number of animal sale or purchase		
			Cock	Hen	Chick
Person No.1	Sale				
	Purchase				
Person No.2	Sale				
	Purchase				
Person No.3	Sale				
	Purchase				
Person No.4	Sale				
	Purchase				
Person No.5	Sale				
	Purchase				

Annex 9 Questionnaire for Trader Survey

Township Survey on Observation of the Animal Production, Animal Health Care System, Trade and Marketing Network in the Central Dry Zone (CDZ) of Myanmar

Survey Objectives

- To observe and describe the traditional animal production system and current animal health care system currently practiced in the Central Dry Zone (CDZ) of Myanmar.
- To observe and describe farmer's attitude and awareness on animal diseases and major cross-species disease transmission in accordance with the one-health paradigm.
- To observe and describe the animal trade and marketing network in the Central Dry Zone of Myanmar
- To find out the most efficient, reliable and relevant solutions for the development of livestock production and one-health paradigm in the Central Dry Zone of Myanmar by analysing the observations from this survey

Declaration

According to the reports, it is found out that the livestock population is very high in the central part of Myanmar than other regions. Due to the reason of getting little rain in the central part of Myanmar, the central part of Myanmar become named as "Central Dry Zone of Myanmar", and people, who live in these areas, cannot rely on agriculture and crop production. As a consequence, the animal production become playing a critical role in the Central Dry Zone. Even though the animal production is popular in these areas, the farmers, practicing the animal production in these areas, have still faced with some dilemmas in their animal production such as animal management, animal diseases and trade. The information collected from the farmer will be confidential. The survey is conducted with the purpose of finding out the current animal production system, animal health problem in order to ensure that recommendation for production is useful for famers; and trade and marketing network in the Central Dry Zone of Myanmar, as part of my PhD study.

QUESTIONNAIRE FOR TRADING PEOPLE

ID NUMBER - ____

<u>Information of Survey</u>

Date (DD/MM/YY) ____

Name of interviewer ____

Position ____

<u>Geographical information</u>

GPS point ______________________________ P-code ________________________

Region ______________________________

District ______________________________

Township ______________________________

Location (Market) ______________________________

Time ______________________________

Date ______________________________

Temperature ______________________________

Rainfall ______________________________

Wind ______________________________

Altitude ______________________________

<u>General Information of the Interviewee</u> (Please tick √ the appropriate box)

Name ________________________________ Age - ( ) years old

Gender - Male ( ) Female ( )

Role of the interviewee in trading -
(Please tick √ the appropriate box)

- [ ] Middleman
- [ ] Trader
- [ ] Farmer
- [ ] Farm manager
- [ ] Hawker
- [ ] Other (--
--)

Type of operation (Please tick √ the appropriate box)

- [ ] Full-time
- [ ] Part-time

Please describe the type of trading you practice.
(Please tick √ the appropriate box)

- [ ] Export trade of livestock
- [ ] Domestic trade of livestock
- [ ] Both

Which of the following animal trading do you have experience in? (Please tick √ the appropriate box)

Type of animal trading	<5 years	5-10 years	>10 years
Cattle			
Sheep			
Goat			
Village chicken			
Other (________________________________)			

Which of the following animal trading do you do today? (Please tick √ the appropriate box)

Species	Trading today	
	Live	Death
Cattle		
Sheep		
Goat		
Village chicken		
Other (Describe________________________)		

Impact of Animal Production on Human Health

Which species of animal do you think can transmit zoonotic disease to human? (Please tick √ the appropriate box)

Cattle ( )

Sheep ( )

Goat ( )

Chicken ( )

Dog ( )

Pig ( )

Others (Describe____)

Which level do you consider the impacts of the risk of transmissible diseases from animal to human on human health? (Please tick √ the appropriate box)

Type of animal production	Very high	High	Moderate	Low	Very low
Cattle production					
Sheep and goat production					
Village chicken production					

Very high = Death High = Severe illness Moderate = Illness Low = Minor sick Very low = Almost no effect

How can you prevent the disease transmission from the animal you are trading to human?

Type of animal production	Please specify
Cattle trading	
Sheep trading	
Goat trading	
Village chicken trading	

What are the main barriers for yourself to prevent the disease transmission from your animals to you and your surrounding?

Type of animal production	Please specify
Cattle trading	
Sheep trading	
Goat trading	
Village chicken trading	

From where do you able to get the information about the information to prevent the disease transmission from your animal to you and your family?

Type of animal production	Please specify
Cattle trading	
Sheep trading	
Goat trading	
Village chicken trading	

Are you confident that you can prevent the transmissible animal disease to human being transmitted from your animal to you and your surrounding? (Please tick √ the appropriate box)

Type of animal production	Not known	Yes	No
Cattle trading			
Sheep and goat trading			
Village chicken trading			

Trading Network

Do you use agents/ middleman/ other traders/ other farmer in trading? (If no, please go Q.66)

☐ Yes ☐ No

If yes in 60, do you usually order a certain number of animal from agent or farmer or middleman?

☐ Yes ☐ No

If yes in 55, do the middleman or famer or middleman usually has holding? OR If you are middleman, please answer it.

☐ Yes ☐ No

Are these source: ____?

☐ Regular
☐ Often
☐ Rare
☐ Other (--)

Do the middlemen usually keep and collect the animal from where they purchase?

☐ Yes ☐ No ☐ Not known

Does each middleman cover a specific area (e.g village, village tract, township, district) in animal trading? OR If you are middleman, do you usually cover a specific area and name the place?

☐ Yes (Name of the place: ____)
☐ No

How do you monitor price of animal?
____

Who and what determine the price of animal?

Who	What

How does the price change and according to what reason?

Difference of price	Area	Reason

What is prices and financial arrangements at the different levels of suppliers/distributers?

☐ Use of credit
☐ Paid employee
☐ Commissioned agent
☐ Trader
☐ Farmer
☐ Other (____)

How does the availability of fund affect the trader's business?
____

Tax and fees to enable you to trade?

Official cost: ____
Unofficial cost: ____

Information on Sale and Purchase

Please list the name of people you directly sell or buy cattle to or from within the two years.

No.	Name	Type of career	Address and contact number	Number of animal	Frequency of trading	Source
1		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others -------- ☐ Main purpose ☐ Only for sale ☐ Only for purchase ☐ Both		______ cattle per time	______ times per month	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (-----------------------------)
				______ sheep per time	______ times per month	
				______ goats per time	______ times per month	
				______ chickens per time	______ times per month	
2		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others -------- ☐ Main purpose ☐ Only for sale		______ cattle per time	______ times per month	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (-----------------------------)
				______ sheep per time	______ times per month	
				______ goats per time	______ times per month	
				______ chickens per time	______ times per month	

No.	Name	Type of career	Address and contact number	Number of animal	Frequency of trading	Source
		□ Only for purchase □ Both				
3		□ Middle man □ Trader □ Neighbours □ Other farmer □ Slaughter house □ Others -------- □ Main purpose □ Only for sale □ Only for purchase □ Both		______ cattle per time ______ sheep per time ______ goats per time ______ chickens per time	______ times per month ______ times per month ______ times per month ______ times per month	□ Your own house □ Cattle market □ Live market □ Slaughter house □ Middleman/Trader house □ Village headman house □ Grazing ground □ Other village (-----------------------------)
4		□ Middle man □ Trader □ Neighbours □ Other farmer □ Slaughter house □ Others -------- □ Main purpose □ Only for sale		______ cattle per time ______ sheep per time ______ goats per time ______ chickens per time	______ times per month ______ times per month ______ times per month ______ times per month	□ Your own house □ Cattle market □ Live market □ Slaughter house □ Middleman/Trader house □ Village headman house □ Grazing ground □ Other village (-----------------------------)

No.	Name	Type of career	Address and contact number	Number of animal	Frequency of trading	Source
		□ Only for purchase □ Both				
5		□ Middle man □ Trader □ Neighbours □ Other farmer □ Slaughter house □ Others -------- □ Main purpose □ Only for sale □ Only for purchase □ Both		______ cattle per time ______ sheep per time ______ goats per time ______ chickens per time	______ times per month ______ times per month ______ times per month ______ times per month	□ Your own house □ Cattle market □ Live market □ Slaughter house □ Middleman/Trader house □ Village headman house □ Grazing ground □ Other village (-----------------------------)
6		□ Middle man □ Trader □ Neighbours □ Other farmer □ Slaughter house □ Others -------- □ Main purpose □ Only for sale		______ cattle per time ______ sheep per time ______ goats per time ______ chickens per time	______ times per month ______ times per month ______ times per month ______ times per month	□ Your own house □ Cattle market □ Live market □ Slaughter house □ Middleman/Trader house □ Village headman house □ Grazing ground □ Other village (-----------------------------)

No.	Name	Type of career	Address and contact number	Number of animal	Frequency of trading	Source
		☐ Only for purchase ☐ Both				
7		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others -------- ☐ Main purpose ☐ Only for sale ☐ Only for purchase ☐ Both		______ cattle per time ______ sheep per time ______ goats per time ______ chickens per time	______ times per month ______ times per month ______ times per month ______ times per month	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (-----------------------------)
8		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others -------- ☐ Main purpose ☐ Only for sale		______ cattle per time ______ sheep per time ______ goats per time ______ chickens per time	______ times per month ______ times per month ______ times per month ______ times per month	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (-----------------------------)

No.	Name	Type of career	Address and contact number	Number of animal	Frequency of trading	Source
		☐ Only for purchase ☐ Both				
9		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others -------- ☐ Main purpose ☐ Only for sale ☐ Only for purchase ☐ Both		________ cattle per time ________ sheep per time ________ goats per time ________ chickens per time	________ times per month ________ times per month ________ times per month ________ times per month	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (-----------------------------)
10		☐ Middle man ☐ Trader ☐ Neighbours ☐ Other farmer ☐ Slaughter house ☐ Others -------- ☐ Main purpose ☐ Only for sale		________ cattle per time ________ sheep per time ________ goats per time ________ chickens per time	________ times per month ________ times per month ________ times per month ________ times per month	☐ Your own house ☐ Cattle market ☐ Live market ☐ Slaughter house ☐ Middleman/Trader house ☐ Village headman house ☐ Grazing ground ☐ Other village (-----------------------------)

No.	Name	Type of career	Address and contact number	Number of animal	Frequency of trading	Source
		☐ Only for purchase ☐ Both				

Please describe the place (villages, townships, etc.) where you collect and sell the animal.

No.	Name of township	Name of village	Number of animal traded per year	Type of animal	Collect/ Distribute	Season
1.			(__________) (__________) (__________) (__________)	☐ Cattle ☐ Sheep ☐ Goat ☐ Village chicken	☐ Collect ☐ Distribute	☐ Summer ☐ Rainy ☐ Winter
2.			(__________) (__________) (__________) (__________)	☐ Cattle ☐ Sheep ☐ Goat ☐ Village chicken	☐ Collect ☐ Distribute	☐ Summer ☐ Rainy ☐ Winter
3.			(__________) (__________) (__________) (__________)	☐ Cattle ☐ Sheep ☐ Goat ☐ Village chicken	☐ Collect ☐ Distribute	☐ Summer ☐ Rainy ☐ Winter
4.			(__________) (__________) (__________) (__________)	☐ Cattle ☐ Sheep ☐ Goat ☐ Village chicken	☐ Collect ☐ Distribute	☐ Summer ☐ Rainy ☐ Winter
5.			(__________) (__________) (__________) (__________)	☐ Cattle ☐ Sheep ☐ Goat ☐ Village chicken	☐ Collect ☐ Distribute	☐ Summer ☐ Rainy ☐ Winter
6.			(__________) (__________) (__________) (__________)	☐ Cattle ☐ Sheep ☐ Goat ☐ Village chicken	☐ Collect ☐ Distribute	☐ Summer ☐ Rainy ☐ Winter
7.			(__________)	☐ Cattle	☐ Collect	☐ Summer

No.	Name of township	Name of village	Number of animal traded per year	Type of animal	Collect/ Distribute	Season
			(____________________) (____________________) (____________________)	☐ Sheep ☐ Goat ☐ Village chicken	☐ Distribute	☐ Rainy ☐ Winter
8.			(____________________) (____________________) (____________________) (____________________)	☐ Cattle ☐ Sheep ☐ Goat ☐ Village chicken	☐ Collect ☐ Distribute	☐ Summer ☐ Rainy ☐ Winter
9.			(____________________) (____________________) (____________________) (____________________)	☐ Cattle ☐ Sheep ☐ Goat ☐ Village chicken	☐ Collect ☐ Distribute	☐ Summer ☐ Rainy ☐ Winter
10.			(____________________) (____________________) (____________________) (____________________)	☐ Cattle ☐ Sheep ☐ Goat ☐ Village chicken	☐ Collect ☐ Distribute	☐ Summer ☐ Rainy ☐ Winter

Annex 10 Manuscripts

10.1 Conference proceeding of the third conference on 3rd international conference on animal health and surveillance, Rotorua, New Zealand, 2017

Multispecies livestock rearing in developing country – a challenge to collect, present and interpret surveillance data

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Abstract

The Central Dry Zone (CDZ) is one of the most important livestock production areas of Myanmar. This region supports 10 million people whose livelihoods depend on small-scale, dry-land agriculture, but it is also one of the poorest regions of Myanmar. Livestock production is a major income source for farmers in the CDZ. Multi-species rearing of livestock is common under the challenging climatic conditions of the CDZ. There is a need to understand the limitations and opportunities for livestock production, health and marketing in the multispecies environment of CDZ in order to develop methods to improve livestock production outputs and to establish a disease surveillance system that addresses the challenges of multispecies rearing. In this research project, quantitative survey techniques were used to compile data on livestock production, health and trading from cattle, sheep and goat and village chicken farmers in 40 villages of the CDZ. Survey-design based regression modelling was used to quantify factors affecting livestock production, biosecurity and health in the CDZ. Our results highlight that livestock management, disease prevention methods, biosecurity practices and even farmer's

awareness towards disease control differ between livestock species ownership groups. The characteristics, constraints and opportunities of species-specific production and marketing have to be considered in order to develop efficient, reliable and relevant strategies to improve production and to establish a holistic disease surveillance system for multispecies livestock rearing households.

Keywords: Livestock production; Central Dry Zone; Small scale farmers; health; livelihood; smallholder

Introduction

Myanmar's economy is dominated by agricultural production with livestock production playing an important role. According to a 2009 World Animal Health Organization (OIE) report, approximately 13 million cattle, 3 million sheep and goats and 135 million poultry are kept in Myanmar [1]. The centre of Myanmar is occupied by the Central Dry Zone (CDZ), a major hub for crop and livestock production, containing almost 50% of Myanmar's livestock population and the majority of the country's 47 official cattle markets. The area comprises alluvial lowlands in a semi-arid tropical environment and is characterised by variable, low annual rainfall of approximately 600–1,000 mm [2]. Small ruminants (goats and sheep) are frequently reared in the CDZ, reflecting these species' adaptability and suitability to the area's climate [3], although cattle and village chicken production dominate livestock rearing in the region.

Some reports describing individual livestock sectors exist [4], however comprehensive research of livestock husbandry and health and, in particular, the ways comparable households raise different livestock species has not been conducted. Approaches that focus on all livestock species within a household, rather than different livestock species in isolation, are particularly important for providing holistic information about how livestock ownership and management may be used to improve the livelihoods of small-scale producers. This is particularly important as infectious diseases, such as Foot and Mouth Disease, can be transmitted between different species within the same household, and trade of multiple species from households can result in a wide range of transmission pathways for infectious pathogens along the market chain.

This study describes multi-species livestock rearing and its contribution to the livelihoods of farmers in the Central Dry Zone (CDZ) of Myanmar. It identifies limitations and opportunities for animal production, health and marketing in the CDZ, which could be further researched or addressed with the aim of improving livestock productivity. This study also identified characteristics of multispecies rearing that have to be considered when conducting disease surveillance in resource-poor households in developing countries.

Materials and Methods

Study design and selection of sampling units

A cross-sectional study was conducted among small-scale farming households owning different livestock species in two administrative areas ('townships'), Myingyan and Meikhtila, in the CDZ of Myanmar. These two CDZ townships were the sites for a broader livestock production and health research project (the 'DAHAT PAN' project), and had been identified as being representative for CDZ livestock production [5]. Two-stage (villages and households) sampling was used to identify households to be included in the survey. The survey's sample size was calculated to estimate the proportion of households deriving at least half their income from livestock assuming an *a priori* prevalence of $\geq$ 70%, precision of ±5%, 95% confidence, and within- and between-cluster variances of ±10% and ±2.5%, respectively, based on a preliminary survey. The software Survey Toolbox was used to estimate the number of villages and households to be sampled [6] – the required sample size was 20 households per village from 38 villages. Probability proportion-to-size sampling [7] was used to select the villages to be sampled from a total of 400 villages across the two townships.

Questionnaire

A questionnaire was developed to collect information on herd/flock structure, husbandry practices, biosecurity measures, household size and demographics, householders' education level, and size and source of household income and assets. Owners were asked to specify the health problems observed in their animals over the preceding two years, which were then grouped according to common clinical syndromes for different body systems. The questionnaire was developed in English and translated into Myanmar/Burmese, and piloted in several villages. The questionnaire survey was conducted by seven trained enumerators.

Statistical Analysis

Data were entered in Microsoft Excel 2013, and checked for data entry errors, validation and reliability. Survey analysis was conducted in Stata 14.0 (Stata Statistical Software, College

Station, Stata Corporation, 2015), accounting for sampling weights, sampling strata (townships) and clustering (villages). Hypothesized causal diagrams between different outcome variables and predictors were created using acyclic graph theory [8] and visualized with DAGitty software [9] by adjusting for direct and indirect effects [10]. Risk factors significant at $P<0.05$ in the univariate analyses were tested in multivariable models using a backward stepwise model building procedure. Multivariable models were compared using the likelihood ratio test (LR), Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). Results of the final models were presented as adjusted odds ratios.

Results

Data were collected from a total of 613 households. Multispecies livestock production within a household was very common. Of the 613 households, 19.6% of household had cattle only, 18.9% of households kept cattle and village chickens, 16.8% of households raised small ruminants only, 15.5% of households had cattle, small ruminants and village chickens, 12.2% of households had village chickens only, 9.2% of households kept cattle and small ruminants, and 7.8% of households small ruminants and village chickens. The median herd or flock sizes were 4 cattle, 30 small ruminants and 10 village chickens. Households owning larger cattle herds (small herd size = 1-3; medium herd size = 4-6; large herd size = >6) were more likely to hire labour (OR: 2.4, 95%CI: 1.3-4.4), and provide supplementary feed in the form of sesame cake in summer (OR: 2.1, 95%CI: 1.1-4.0) and maize in winter (OR: 2.1, 95%CI: 1.2-3.7) However, these management practices were less common for goat and sheep holdings, where the odds ratios for labour hiring, and sesame and maize feeding in large herds/flocks compared to smaller ones were 0.5 (95%CI: 0.3-0.99), 0.3 (95%CI: 0.1-0.8) and 0.2 (0.1-0.7), respectively.

Natural mating was the most common livestock breeding method in the CDZ. About half (57%, 95%CI: 50.0-63.2) of all cattle farms sourced bulls from the same village, although 27% (95%CI: 22.1-34.0) used bulls from other villages. 13.4% (95%CI: 9.4-18.6) of households used their own bull; only 0.5% (95%CI: 0.1-3.3) of households used artificial insemination. In contrast, the large majority (86% (95%CI: 81-89%)) of small ruminant-owning households used males from within their own household herds/flocks, with only 14% (95%CI: 10-18%) and 1% (95%CI: 0.3-3%) of households sourcing males from elsewhere in the same village or another village, respectively.

Fewer efforts were made to improve the health of village chickens compared to large or small ruminants. More than half (52%, 95%CI: 46-61%) of village chicken owners would not conduct any treatment of sick chickens, while only 6.6% (95%CI: 4.3-10.0) and 3.9% (95%CI: 2.1-7.2) of cattle and small ruminant owners would not treat their sick animals, respectively. If treatment was conducted, the majority of small ruminant (64.1%) and village chicken (91.1%) owners relied on traditional medicine. Conversely, the majority of cattle farmers used a veterinary healthcare provider alone or in combination with traditional medicine. Interestingly biosecurity practices differed between livestock ownership groups ($p<0.0001$), with cattle owners (28.7%, 95%CI: 23.0-35.3), small ruminant owners (63.3%, 95%CI: 55.7-70.4) and poultry farmers (69.7%, 95%CI: 62.6-75.9) conducting any of the followings: reducing contact with sick animal, reducing the entry of people, quarantine the sick animal, disinfection and regular cleaning the farm. Segregation of sick animals was more common for cattle owners (43.9%, 95%CI: 38.1-49.9) and small ruminant owners (34.0%, 95%CI: 25.9-43.1) than village chicken owners (24.6%, 95%CI: 18.0-32.6).

Respiratory problems (coughing, sneezing, discharge from the nose or other disorders of breathing) were most commonly reported for cows and calves, with 26% (95%CI: 21-32%) and 12% (95%CI: 8-18%) of animals showing signs in the last two years, respectively. Digestive system problems (including drooling, sores in mouth, anorexia, constipation, painful abdomen and diarrhoea) were most commonly reported in bulls (33%, 95%CI: 42-71%). Conversely, digestive system problems were most frequently reported in young small ruminants, affecting nearly half of all animals (46%, 95%CI: 37-55%). Respiratory problems were more common in adult small ruminants, affecting 49% (95%CI: 42-56%) of does/ewes and 37% (95%CI: 29-45%) bucks/rams. In village chickens, ‘physical’ abnormalities (twisted head or neck, slow growth, weakness, frequent lying down, mechanical injuries) affected about one quarter of birds from different age/sex groups: 26% (95%CI: 19-33%) in chicks; 28% (95%CI: 21-37%) in hens; and 26% (95%CI: 19-35%) in cocks. There were differences in likelihood of health problems occurring depending on the size of the livestock holding. The majority of cattle farmers (81.2%, 95%CI: 76.4-85.3), 74.4% (95%CI: 66.8-80.7), small ruminant farmers and poultry farmers 67.8% (95%CI: 61.2-73.8) were aware of the effectiveness of vaccinations (FMD and ND). However, the major constraint for conducting vaccinations in cattle (17.4%, 95%CI: 12.7-23.3) and poultry (14.9% 95%CI: 10.3-21.1) were limited financial resources while small ruminant farmers highlighted their limited knowledge about vaccinations (21.4%, 95%CI: 15.9-28.2). Nevertheless, the majority of cattle farmers

(87.0%, 95%CI: 80.8-91.4) small ruminant farmers (75.9%, 95%CI: 65.8-83.7) and poultry farmers (68.9%, 95%CI: 61.5-75.5 of) were willing to have their livestock vaccinated.

Discussion

The main goal of the current study was to provide more detailed descriptions of livestock ownership, husbandry and health in the CDZ of Myanmar. Despite the country's rapid recent social change and improved connection with the outside world, livestock production still mainly follows traditional methods. No single species dominated household ownership, and multiple species, even of different kinds of ruminants, were frequently owned by households. This suggests that livelihood development strategies should address the potential for multiple income sources within a household. Such strategies may also have wider benefit if they can exploit synergies between production practices and knowledge for different species—for example, ensuring that training to improve livestock nutrition identifies concepts that apply to both goats and cattle. Likewise, differences in seasonal patterns of grazing for large and small ruminants deserve further investigation to understand whether constraints or opportunities in one species' grazing management could be addressed for another's. Similarly, approaches to improve biosecurity and enhance disease control have to address all pathways for disease introduction and spread that come with rearing different livestock species within one household. The differences in farmer attitudes to investing extra in labour or feed for cattle compared to small ruminants are very interesting. The willingness of owners of larger cattle herds to spend more in these areas may reflect their greater wealth or financial insight. On the other hand, larger small ruminant herds/flocks may present an increasing financial challenge to farmers, making them reluctant to spend money to support productivity as their livestock holdings increase. This is a critical issue that must be addressed, as development strategies often seek to increase holdings of small ruminants by households. Our results suggest that farmers may be unwilling to invest in extra resources to support increased productivity as their holdings grow.

The observations reported by farmers of their animals' health help identify body systems and a smaller set of potential diseases that could be targeted for investigation. This allows limited resources to be used more efficiently to better understand disease constraints on productivity. Similarly, this insight could be used to direct training or limited health surveillance resources to where it is likely most needed. On the hand, training workshops for farmers could cover various livestock species at the same time, thereby comparing appropriate approaches for different livestock species to improve their productivity and health.

Smallholders appear to generally have poor access to veterinary services for small ruminants and village poultry, or are unwilling to spend money on these treatments compared to traditional ones. Furthermore, owners of all species appear to have poor access to knowledge and resources to manage the health of their animals. In addition income generated from more valuable livestock species, such as cattle, might also result in higher disease reporting efforts by farmers compared to less valuable livestock, such as chickens (which are also 'traded' as dead animals). Developing a disease surveillance system for multispecies rearing households has to synergistically address these challenges.

Whilst identifying important limitations to animal production in Myanmar's CDZ, this study also highlighted issues that have to be considered when conducting surveillance of production and health parameters in multispecies households.

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Characteristics of Livestock Husbandry and Management Practice in the Central Dry Zone of Myanmar

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Abstract

The Central Dry Zone (CDZ) of Myanmar is the area with the highest density of small scale livestock farmers under harsh environmental condition. In this study, we describe and quantify ownership patterns for various livestock species and characterised management and husbandry practices of small-scale farmers. In addition, we identify the husbandry factors associated with selected outcome indicators, 'herd or flock size' and 'purpose of rearing'. A total of 613 livestock farmers in 40 villages were interviewed. Multispecies rearing was common with 51.7% of farmers rearing more than one livestock species. Rearing animals to be sold as adults for slaughter (meat production) was more common for small ruminants (98.1%) and chickens (99.8%) compared to cattle (69.8%). Larger cattle herds were more likely to practice grazing (*p*<0.001) and to employ labour from outside the household to manage cattle than medium or small herds (p=0.03). Patterns of grazing differed significantly between seasons (*p*<0.01) for cattle, but not for small ruminants,

while patterns of scavenging by chickens did also not vary seasonally. Active breeding management was common in livestock enterprise in CDZ where inbreeding was common in small ruminant industry whereas outbreeding was highly reported breeding method in cattle farms. Overall, multispecies rearing and species-specific husbandry practices are used to raise livestock under harsh environmental conditions. Our results reveal that herd/flock size, and purpose of rearing across different livestock species were significantly associated with feeding and housing practices and experience of farmers.

Keywords: small-scale livestock; environmental challenges; Central Dry Zone (CDZ); cattle; small ruminants; village chicken

Introduction

Typically, descriptions of livestock production systems concentrate on one species of animal, although households in developing countries might keep multiple species and interrelationships in the management and management are likely to exist. In addition, livestock production in developing countries is often constrained by poor husbandry, inadequate housing, and poor breeding, health and biosecurity practices (Homann, Van Rooyen et al. 2007, Conan, Goutard et al. 2012, Nampanya, Suon et al. 2012, Conan, Ponsich et al. 2013, Gillette 2013). Thus, in resource poor household keeping multiple livestock species, investments into feeding and housing might need to be spread across various livestock species, and might limit increases of income generated from livestock production. It has been shown that famers' income is largely influenced by herd size (Bailey, Hardin et al. 1997, Oleggini, Ely et al. 2001, McPeak 2004, Maltsoglou and Rapsomanikis 2005) and understanding factors that impact on herd size, in particular in multispecies households, is critical for rural livestock development (Loibooki, Hofer et al. 2002, Kaimba, Njehia et al. 2011). In addition, although most livestock species are raised predominately for sale, others are more important for home consumption or provision of draught power (Alam 1997, Kristjanson, Krishna et al. 2004, Yamamoto 2004, Moll 2005) and identifying husbandry factors impacting on these purposes of livestock rearing, is crucial to develop appropriate interventions.

Little is known about livestock production in Myanmar, despite its great importance in Southeast Asia: approximately 13 million cattle, 3 million sheep and goats, and 135 million poultry were kept in Myanmar in 2009 (OIE 2009). Livestock in Myanmar is mainly reared on ‘backyard farms’ in villages, with feeding provided in traditional ways such as grazing common fallow areas within and around villages, scavenging in the village environment and utilizing standing crop residues and by-products (Devendra, Thomas et al. 1997, Devendra and Thomas 2002, Devendra and Thomas 2002, Henning, Pym et al. 2007, Oo 2010). The Central Dry Zone (CDZ) is a major hub for crop and livestock production in which almost 50% of Myanmar's livestock population is reared. This region supports 10 million people whose livelihoods depend on small-scale, dry-land agriculture, but it is also one of the poorest regions of Myanmar. Even though livestock production is a major income source for farmers in the CDZ, there is an eminent lack of information on livestock husbandry practices, nutrition, animal health problems, the socio-economic impact of livestock production and the current trading system in CDZ of Myanmar.

In this study, we described ownership patterns for various livestock species and characterised management and husbandry practices of small-scale farmers. We then selected ‘herd or flock size’ as a measure describing the ‘wealth’ of farmers, but also reflecting the success of livestock production and identified factors management and husbandry practices impacting on establishing larger herd or flock sizes. We also explored factors that impact on ‘purposes of livestock rearing’ because it describes the diversity of benefits that can be derived from livestock rearing.

Methods

Study design

A cross-sectional study involving small-scale farming households owning different livestock species was conducted in the Central Dry Zone (CDZ). The study took place during November to December, 2014 in two administrative areas (‘townships’), Myingyan and Meikhtila, of the CDZ. These two townships were identified as representative of CDZ livestock holdings, production systems and environment, and were associated with a livestock production and health research project (AH/2011/054) funded by Australian Centre for International Agriculture Research (ACIAR) (ACIAR 2014).

Sample size calculation and selection of sampling units

A two-stage sampling approach was used, with villages ('clusters') and households comprising the two sampling stages. The proportion of farm income generated from livestock production was used as the outcome of interest for the sample size calculations, conservatively assumed to be 50%, with within- and between-cluster variances of ±10% and ±2.5%, respectively. The low between-cluster variance reflected the very similar ecological conditions resulting in similar income generation from livestock production across villages in the CDZ. The estimated sample size was 20 households per village and 38 villages across the two townships, assuming that the proportion of farmers in a village deriving at least half of their income from livestock production was 0.7, a population of 400 villages per township and approximately 200 households per village based on livestock statistics data compiled by the Myanmar Livestock, Breeding and Veterinary Department (LBVD) (LBVD 2014). The precision of the estimate was set to ±5% with a 95% confidence interval. Lists of villages were provided by LBVD. In order to select villages, a probability-proportional-to-size sampling strategy was used (http://epitools.ausvet.com.au/content.php?page=2StagePrevalence1), giving larger villages a greater probability of being selected; a total of 40 villages were selected in each township (20 villages to be selected and 20 potential replacement villages). Within selected villages, lists of households for each of the three major livestock species (cattle, small ruminates and village chickens) were provided by village headmen. Selected villages were replaced if they had insufficient households with the three livestock species of interest or if farmers were not willing to participate in the study. Seven households from each livestock ownership list were randomly selected, providing a total of 21 households per village. If farmers in selected households refused to participate in the study, replacement households were randomly selected. Sample size calculations and random sampling were performed using the Survey Toolbox modules Sample size for 2-stage prevalence survey, Random sampling from a sampling frame (http://epitools.ausvet.com.au/content.php?page=Random Sampling1) and Random sampling of animals, respectively (http://epitools.ausvet.com.au/content.php?page=RandomSampling2) (Sergeant 2014).

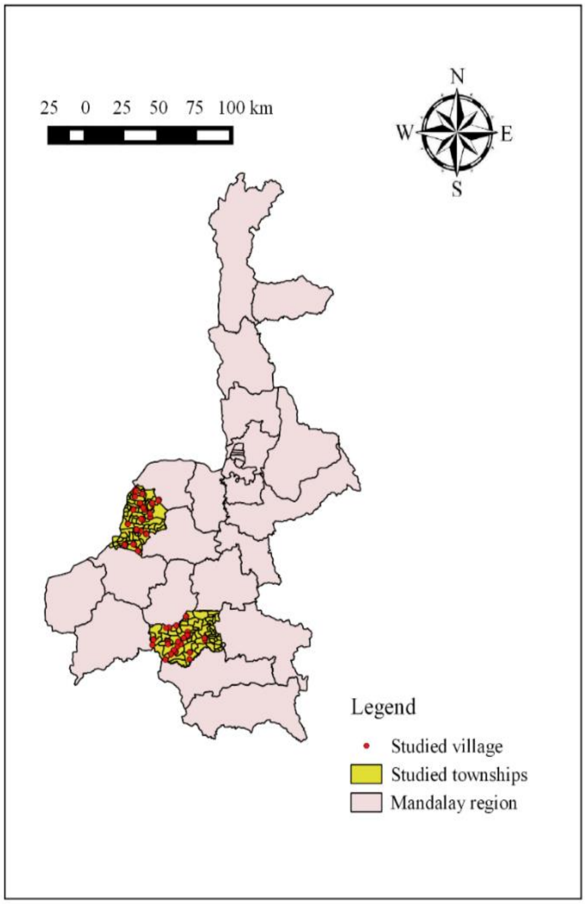

Figure 1 Map of the Mandalay region of Central Dry Zone of Myanmar with two townships (Meikhtila and Myingyan) where research on multispecies livestock rearing was conducted highlighted in yellow (insert shows Map of Myanmar with Mandalay region

Livestock husbandry questionnaire

The ethical approval for conducting the interviews with framers was provided by the University of Queensland Human Research Ethics Committee (approval number #2014001425). A questionnaire was used to collect demographic details of farmers, information on herd structure, husbandry practices, and purpose of rearing. The questionnaire was developed in English and translated into the local language (Myanmar/Burmese). The questionnaire was piloted in six households owning multiple livestock species (cattle, goats and chickens) across two villages—one relatively poorer and one more affluent—in Meikhtila Township. After the pilot testing, a total number of 32 questions were modified. Questions on home asset scores and feeding and housing were adjusted to be more relevant to the local conditions and to improve farmers' understanding of the questions. The final questionnaire had 34 questions for each livestock ownership groups, and the average duration of an interview was approximately one hour. The survey was conducted from November 2014 to January 2015. The interviews were conducted by seven enumerators, comprising of Myanmar University of Veterinary Science postgraduate students and Livestock, Breeding and Veterinary Department (LBVD) staff. All enumerators were trained in the survey and interviewing techniques before the survey commenced.

Survey design data structure

Categorisation of variables

The number of animals kept per herd or flocks was examined by tercile analysis, and the 33^{rd}, 66^{th}, 100^{th} percentile was used to describe herd/flock sizes. Herds/flocks were classified into three sizes (small, medium, large), corresponding to these terciles for each livestock species: cattle herds - small (1-3 head), medium (4-6) and large (>6); small ruminant flocks - small (1-20), medium (21-40) and large (>40); and village chicken flocks - small (1-7), medium (8-14) and large (>14).

Purposes of cattle rearing were specified by farmers as ‘meat production (i.e. sale of adult animals for slaughter)’, ‘milk production’, ‘draught power’, ‘breeding and sale of offspring’ and ‘manure used for fertilizer’. Cattle rearing for ‘meat production’, ‘breeding’ and/or ‘milk production’ was combined into the category of ‘cash commodity’ purpose; cattle rearing for ‘draught power’ and ‘manure for fertilizer’ into the category of ‘agriculture focus’ purpose; and the combination of any these two categories was regarded as ‘multipurpose' cattle rearing. As chickens and chicken products (eggs) and small ruminants and their products (milk) were only used by farmers for sale and home consumption, we were not able to categorize purposes of livestock production for these two livestock species as summary measure ‘purpose of livestock rearing’ focused on purposes that generate income for the household.

Statistical analysis

We considered seven different types of livestock ownership: rearing either cattle, small ruminants or village chickens alone, rearing combinations of two livestock species or rearing all three livestock species together.

Data checking and validation was conducted by using NVivo Pro 11. Data were analysed using survey design commands in Stata 14.0 (Stata Statistical Software, College Station, Stata Corporation, 2015) to account for the two-stage study design, with sampling weights, sampling strata (townships) and clustering effects (villages) specified beforehand (Nathan and Holt 1980, Deaton 1997). The primary sampling units (PSUs) were villages within the townships, and the secondary sampling units (SSUs) were households within these villages. Sampling weights for the household and village level represented the inverse of the probability of being sampled (StataCorp LP 2014). Taylor linearization was used for variance estimation (VCE) (Cochran 1977, Wolter 2007), with a finite population correction (FPC) used for each sampling level by specifying the total number of villages and the total number of households. Two different sampling weights were used for the household and village level, representing the reverse of the probability of being sampled. The PSUs (villages) were also stratified into two strata (townships), addressing decreasing variability as sampled villages are more homogenous within the strata than between the strata (Skinner, Holt et al. 1989, Heeringa, West et al. 2010, Levy and Lemeshow 2013). Finite population corrections (FPC) were applied for each level, representing the number of total villages and households in the studied areas. This allowed accounting for the reduction in variance by comparing sampling without population replacement from a finite population with sampling with replacement from the same population (Cochran 1977).

The proportion of farmers having different herd/flock sizes categories (small, medium, large) and the proportion of framers conducting different management practices (e.g. housing, feeding and breeding practices) was compared between livestock ownership groups using the Pearson $\chi 2$ Statistics, which was converted into F-statistics accounting for the survey design (Koch, Freeman Jr et al. 1975, Rao and Scott 1984). In addition, the proportion of farmers conducting seasonal feeding for each livestock species was also compared using the survey-design converted F-statistic.

To identify factors that influence herd/flock size (low-medium-high) and the purpose of livestock rearing ordinal logistic regression and multinomial logistic regression models were built for each livestock enterprise (cattle, small ruminants and chickens). The proportional odds ratio assumption for the use of ordinal regression was assessed using the likelihood ratio test (-omodel- command in STATA) and the Brant test (-brant- command in STATA) (Sloane and Morgan 1996, Paxton 1999, Long and Freese 2006, Agresti and Kateri 2011). A non-significant result would indicate that parallel regression or proportional odds assumption is not violated (IRDE 2016). Similarly, nominal regression was used to identify livestock management practices that were associated with purpose of cattle rearing.

Management factors significant at $p<0.05$ in the univariable analyses were included in the multivariable analyses in an initial forward selection and then backward elimination building procedure until all variables were significant at $p<0.05$. The Wald test was used to assess the joint significance of variables with more than 2 levels. The final, best-fitting model was selected as the one with the lowest Akaike Information Criterion (AIC).

Results

Dataset for analysis

It was aimed to collect data from seven households owning each of the three-livestock species in each of the 40 villages, representing 280 households for each species and 840 households altogether. However, many of the households selected from the sampling frame of cattle, small ruminant or village chicken owners, also kept other livestock species, and we also collected data for these additional species in the same household. As a result, fewer individual households were surveyed, with a total 613 household owners were interviewed, with cattle being raised in 382, small ruminants in 303, and village chicken in 327 households.

Men comprised 49.8% (95%CI: 44.2-55.4) of the interviewees, and 50.2% (95%CI: 44.6-55.9) were women. The mean age of the respondents was 47 (range 12-84) years.

62.3% of survey households owned cattle, followed by village chicken (53.3% of 613 households) and small ruminant (49.4% of 613 households). Mixed livestock rearing was common, with 311 (51.7% of 613 households) households rearing more than one livestock species (Figure 1). Of the 613 households, 19.6% of households had cattle only, 18.9% of households kept cattle and village chicken, 16.8% of households raised small ruminant only, 15.5% of households raised cattle, small ruminant, and village chicken together, 12.2% of households had village chicken only, 9.2% of households had cattle and small ruminants and 7.8% of households raised small ruminant and village chicken.

Approximately three-quarters of the cattle and two-thirds of village chicken owners raised these species for more than 10 years, while the majority of small ruminant farmers (in particular sheep farmers) had less than 5 years' experience (Supplementary table 1).

Herd or flock size

Herd/flock sizes across different livestock ownership categories are shown in Figure 2. The median herd size for cattle was 4 animals (IQR: 2-7), comprising of one male calf (range 1-5), one female calf (range 1-10), one cow (range 1-30) and one bull (range 1-23). For small ruminants, the median size was 30 (IQR: 15-41), comprising of three (range 1-30) male offspring, four (range 1-30) female offspring, 17 (range 1-65) adult females and two (range 1-50) adult males. The median village chicken flock size was 10 (IQR: 5-18), comprising seven (range 1-400) chicks; two (range 1-30) hens and one (range 1-17) rooster. There was no significant difference in the proportion of households with 'Small, 'Medium' or 'Large' herds/flocks of cattle, small ruminants or village chickens across the different livestock ownership groups (p = 0.34, 0.51 and 0.79 for cattle, small ruminant and village chicken ownership groups, respectively; Table 2).

Purpose of raising livestock

Livestock species were reared for different purposes. The majority of cattle farmers conducted cattle raising for multiple purposes (50.8%), followed by raising them for draught power for crop production (33.5%), while rearing cattle for sale was less common (15.7%). Manure from cattle was used by 56.7% of cattle-rearing households as fertilizer. Breeding small ruminants for the sale of offspring (88.1% of 303 small ruminant farmers) was more common than for cattle (74.2% of 382 cattle farmers). About one-third of households kept cattle (31.6%) or small ruminants (28.6%) for milk production. Cattle and small ruminants were not raised for home consumption. Rearing animals to be sold as adults for slaughter (meat production) was more common for small ruminants (98.1%) and chickens (99.8%) compared to cattle (69.8%). Village chickens were predominately raised for the cash sale of live birds (77.2% of 327 households), followed by home consumption (22.6%) and cockfighting (0.2%).

Livestock husbandry characteristics

Raising cattle, small ruminants or village chickens alone, with one other livestock species or all three livestock species together did not influence the nutritional management (i.e. grazing practices, provision of supplementary feed and water). Similarity, grazing was common for both, cattle (~70% of 382) and small ruminants (~90% of 303), whereas provision of cut and carry grass was more frequently conducted for cattle (~50%) compared to small ruminants (~2%). Patterns of cattle grazing differed significantly between seasons ($p<0.01$). Seventy-four percent of cattle herds were taken out for grazing in the rainy season (June-October) and winter (November-February), whereas only 62.0% of herds grazed in the summer months (March-May; Table 1). Providing supplementary feed to cattle was more common (>50% of HH) during summer and then decreased (<50%) in the winter and rainy seasons. In contrast, no seasonal differences were observed for small ruminant grazing, with approximately 98.0% of small ruminant flocks grazing in summer, the rainy season and winter alike. Similarly, there were no seasonal differences in nutritional management of village chickens, with 90.0% of village chicken flocks scavenging in all three seasons of the year. Additional feed such as rice (90.0%), food scraps (48.0%), maize/sorghum (25.0%) and broken rice (10.0%) were provided. Wells were the most common source of drinking water for all species (70.0-80.0%). No water was provided at home to approximately 5% of ruminant herds and 13% village chicken flocks (Table 1).

Ruminants were generally provided with some form of shelter structure (cattle: 82.2%; small ruminants: 93.0%), while only 12.8% of farmers provided shelters to village chicken. A larger proportion of cattle (82.2%) and small ruminant farmers (93.0%) provided overnight shelters for animals. A large proportion of cattle and small ruminants provided shelter with natural material whereas the provision of shelter to village chicken was scarce (Supplementary table 2). However, housing was more likely to be provided to cattle and small ruminants when they were kept alone, rather than in combination with other species ($p = 0.058$ for cattle; $p = 0.0218$ for small ruminants; Table 2).

Amongst ruminant-owning households, 56.8% (217 of 382) cattle households and 89.8% (272 of 303) small ruminant households used some form of breeding management. Cattle households commonly (86.7% or 188 of 217) used a bull from outside the household for mating, but was very common amongst small ruminant owners (87.1% or 237 of 272). Of 217 cattle owners, 56.7% used a bull from the same village for breeding, 27.7% used bulls from other villages, and 1.8% used both their own bull and a bull from other villages while 13.3% had no active mating management. In contrast, of the 272 small ruminant farmers, 11.8% used a male from the same village, and 1.1% used a male from other villages whereas the rest of the farmers (87.1%) largely relied on males from within their own herd. Only 0.5% of cattle farmers used artificial insemination (AI), while no AI was conducted in small ruminants.

Castration was more common in cattle households (64.9%, 227 out of 342) compared to small ruminant households (5.0%, 18 out of 297). Usually, older cattle were castrated, with 97.4% older than 12 months at the time of castration, and only 1.4% and 1.2% at 6-12 months and < 6 months, respectively. Out of the 18 small ruminant farmers practicing castration, 49.6% conducted castrations in animals older than 12 months, while 34.2% at 6-12 months and 16.2% at younger than six months.

Table 1 Seasonal variation of feeding and water provided to livestock in the Central Dry Zone of Myanmar

No.	Feeding practice	Categories	Cattle		Small ruminants		Village chickens	
			N	Proportion with 95% CI	N	Proportion with 95% CI	N	Proportion with 95% CI
1.	Use of grazing areas	Summer	382	62.1* (54.2-69.4)	303	98.4 (95.2-99.5)	N/A	
		Rainy season	382	74.4 (66.8-80.8)	303	98.4 (95.2-99.5)		
		Winter	382	73.2 (66.0-79.3)	303	98.4 (95.2-99.5)		
2.	Provision of cut and carry local fodder grass	Summer	382	29.1* (22.9-36.1)	303	1.6 (0.5-5.4)e to	N/A	
		Rainy season	382	78.1 (71.8-83.3)	303	1.6 (0.5-5.4)		
		Winter	382	74.2 (67.8-79.7)	303	1.4 (0.3-5.4)		
3.	Provision of rice straw	Summer	382	47.2* (38.2-56.4)	303	1.9 (0.6-5.8)	N/A	
		Rainy season	382	13.9 (9.9-19.3)	303	1.9 (0.6-5.8)		
		Winter	382	12.4 (8.7-17.4)	303	1.9 (0.6-5.8)		
4.	Provision of crop residue**	Summer	382	71.3* (66.3-75.9)	303	11.7 (6.6-20.0)	N/A	
		Rainy season	382	41.6 (35.0-48.4)	303	10.8 (6.2-18.4)		
		Winter	382	43.5 (37.6-49.7)	303	10.5 (6.0-17.8)		
5.	Provision of groundnut cake ***	Summer	382	47.0* (38.2-56.0)	303	1.9 (0.7-5.4)	N/A	
		Rainy season	382	23.1 (17.9-29.3)	303	1.7 (0.5-5.3)		
		Winter	382	27.2 (21.3-33.9)	303	1.7 (0.5-5.3)		
6.	Provision of sesame cake***	Summer	382	54.9* (46.2-63.2)	303	1.4 (0.4-4.7)	N/A	
		Rainy season	382	27.7 (22.2-34.1)	303	1.1 (0.3-4.8)		
		Winter	382	28.0 (22.2-34.7)	303	1.1 (0.3-4.8)		
7.	Provision of maize or sorghum straw	Summer	382	67.4* (63.4-71.1)	303	2.3 (0.8-6.1)	N/A	
		Rainy season	382	55.5 (50.9-60.0)	303	2.3 (0.8-6.1)		
		Winter	382	58.3 (53.1-63.3)	303	2.0 (0.7-5.5)		
8.	Free range scavenging	Summer	N/A		N/A		327	88.7 (80.8-93.6)
		Rainy season					327	90.6 (82.9-95.1)
		Winter					327	90.2 (83.1-94.5)
9.	Provision of rice	Summer	N/A		N/A		327	88.7 (83.2-92.6)
		Rainy season					327	90.8 (86.4-93.9)
		Winter					327	92.3 (88.0-95.2)
10.	Provision of broken rice	Summer	N/A		N/A		327	10.7 (6.4-17.3)
		Rainy season					327	10.0 (5.8-16.5)
		Winter					327	9.7 (5.6-16.2)
11.	Provision of peas	Summer	N/A		N/A		327	6.3 (3.0-12.6)
		Rainy season					327	6.1 (2.8-12.7)
		Winter					327	5.8 (2.6-12.4)
12.	Provision of household scrap	Summer	N/A		N/A		327	47.7 (38.8-56.8)
		Rainy season					327	45.7 (38.1-53.5)

No.	Feeding practice	Categories	Cattle		Small ruminants		Village chickens	
			N	Proportion with 95% CI	N	Proportion with 95% CI	N	Proportion with 95% CI
		Winter					327	47.8 (39.5-56.2)
13.	Provision of maize	Summer		N/A		N/A	327	25.7 (19.1-33.7)
		Rainy season					327	22.9 (17.3-29.7)
		Winter					327	24.3 (17.9-32.0)
14.	Provision of water	Not provided	382	4.7 (2.7-8.0)	303	4.6 (2.3-8.9)	327	13.3 (8.2-20.8)
		River		0.9 (0.1-5.8)		2.8 (1.1-7.0)		1.0 (0.2-6.5)
		Well		78.6 (71.1-84.6)		68.1 (60.5-74.8)		69.7 (59.3-78.4)
		Lake		12.0 (7.4-18.9)		14.5 (9.7-21.1)		6.3 (3.5-11.0)
		Tap water		0.9 (0.3-2.9)		2.1 (0.7-6.6)		1.5 (0.4-5.9)
		Other		2.9 (1.7-5.2)		8.0 (4.9-12.8)		8.3 (4.7-14.1)

(Legend: Summer = March-May; Rainy season = June-October; Winter = November-February)

*Chi-square with significant level of * = $p<0.05$* to identify seasonal effect; ******By-products of first-stage processing of the harvested plants i.e., threshing and winnowing**; ***** By-products of second-stage processing of a plant part, usually what’s left over from oil extraction.

Table 2 Husbandry practices employed by households owning cattle, small ruminant or village chicken singly or in combination with other species *: $p<0.05$; a: F-statistics = 2.7 (Comparison of provision of shelter across different livestock enterprises)

Type of livestock enterprise		Provision of shelter (%)	Practice grazing (%)	Provision of any supplementary feed at home (%)	Herd/flock size			
					Small	Medium	Large	Median
Husbandry practice of cattle in households owning cattle singly or with other livestock species								
CTL	*only* (N = 125)	91.4%	71.6%	90.8%	38.3%	39.4%	22.3%	4
	+ *SR* (N = 55)	74.2%	81.3%	71.4%	38.5%	38.7%	22.9%	4
	+ *CHK* (N = 114)	77.6%	78.5%	84.6%	37.3%	29.8%	32.9%	4
	+ *SR* + *CHK* (N = 88)	79.6%	77.0%	83.0%	53.5%	23.1%	23.3%	3.5
Husbandry practice of small ruminant in households owning small ruminant singly or with other livestock species								
SR	*only* (N = 106)	96.1%*[a]	98.8%	14.5%	24.0%	50.2%	25.8%	30
	+ *CTL* (N = 55)	87.35%*[a]	97.1%	10.2%	35.4%	42.0%	22.6%	29
	+ *CHK* (N = 54)	97.6%*[a]	0.0%	10.4%	20.3%	45.7%	34.0%	30
	+ *CTL* + *CHK* (N = 88)	89.8%*[a]	97.7%	14.5%	33.9%	37.7%	28.4%	26
Husbandry practice of village chicken in households owning village chicken singly or with other livestock species								
CHK	*only* (N = 71)	10.0%	94.1%	98.1%	32.6%	31.2%	36.2%	11
	+ *CTL* (N = 114)	10.6%	88.7%	92.7%	32.3%	36.7%	31.0%	10
	+ *SR* (N = 54)	19.3%	90.7%	98.4%	32.2%	34.1%	33.7%	9
	+ *CTL* + *SR* (N = 88)	12.8%	82.7%	98.5%	44.0%	24.5%	31.5%	11

CTL = Cattle; SR = Small ruminant; CHK = Village chicken

Husbandry characteristics associated with purpose of cattle rearing

Univariate analysis results for purpose of rearing are shown in Supplementary table 4. However, in the final multinominal multivariable model, there was only an association between the purpose(s) of keeping cattle and cattle grazing. Compared to cattle kept only for draught power and production of fertilizer, grazing was more common for cattle kept for multiple purposes (OR: 7.3, 95%CI: 3.6-15.0) or exclusively for cash sales (OR: 6.9, 95%CI: 2.2-22.3) (p<0.01). Predicted probabilities for practising grazing across the three purposes of cattle rearing are shown in Supplementary figure 1.

Husbandry characteristics associated with herd or flock size

Larger cattle herds were more likely to practice grazing (p<0.001) and to employ labour from outside the household to manage cattle than medium or small herds (p=0.03; Table 3). In addition, larger cattle herds were more likely to be raised for multiple purposes (draught power production of fertilizer combined with sale of offspring) compared to the sale of offspring alone (p< 0.05). Amongst small ruminant households, larger herds/flocks were kept by farmers with longer experience of small ruminant ownership (p=0.003). Farmers keeping larger small ruminant flocks were more likely to use their own males for breeding, rather than males from other flocks (p<0.001). For village chickens, only the provision of drinking water to birds was associated with larger flock sizes (p=0.045).

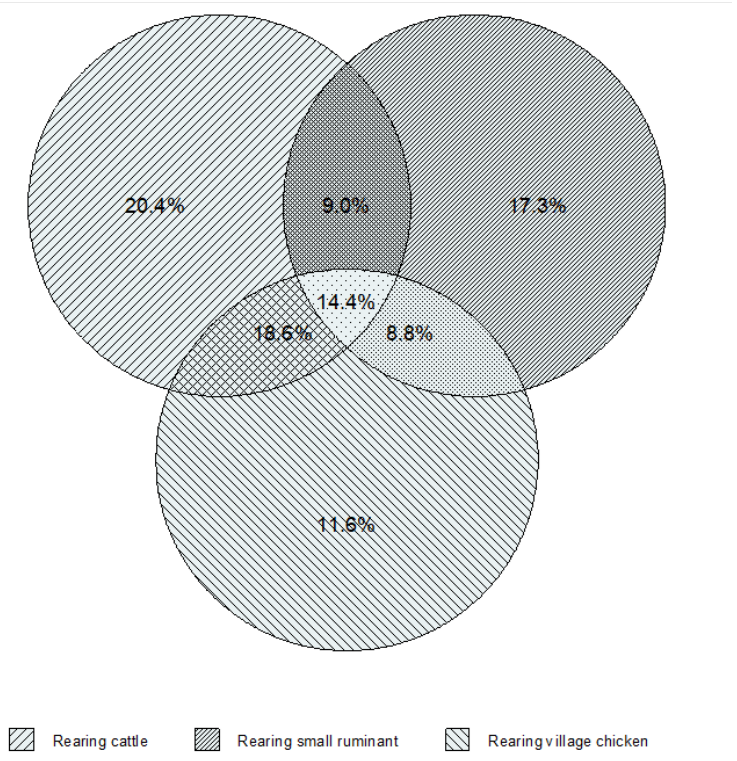

Figure 2 Proportion of farmers (Cattle farmers: 382; Small ruminant farmers: 303; Village chicken farmers: 327) reporting the type of livestock species reared in their farms

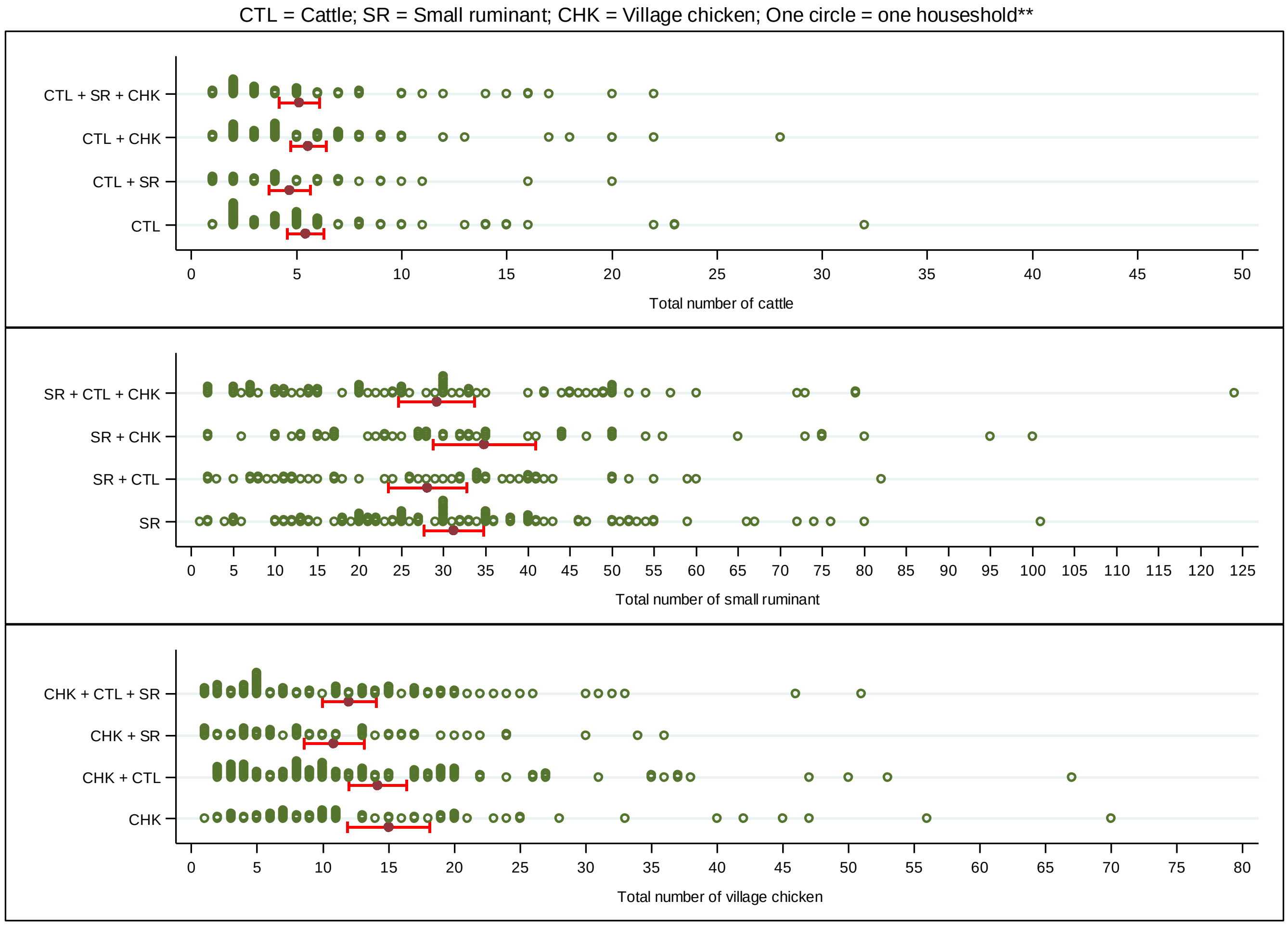

Figure 3 Distribution of cattle (CTL), small ruminants (SR) and village chicken (CHK) herd or flock sizes by livestock-ownership groups in the Central Dry Zone of Myanmar. Red horizontal bar indicates the mean herd/flock size with 95% confident interval.

Table 3 Final models of factors associated with the herd/flock size of cattle, small ruminant and village chicken

Variables	Categories	N	Percentage (%)			OR	p-value	Wald test
			Low	Medium	High			
Outcome variable: Cattle herd size Low (1-3 heads) - 156 (40.9%) Medium (4-6 heads) - 130 (34.0%) High (>6 heads) - 96 (25.1%)								
Purpose of rearing	Cash commodity	382	56.9	57.7	22.1	1		0.0001
	Agriculture focus		21.1	32.8	37.0	1.2 (0.4-3.6)	0.685	
	Multipurpose		22.1	9.6	40.9	4.2 (1.8-9.9)	0.002	
Hire labour	No	382	91.0	83.7	76.0	1		-
	Yes		9.0	16.3	24.0	2.1 (1.1-4.0)	0.030	
Practice grazing	No	382	39.7	21.1	1.3	1		-
	Yes		60.3	78.9	98.7	4.3 (2.0-9.5)	0.000	
Outcome variable: Small ruminant herd size Low (1-20 heads) - 100 (33%) Medium (21-40 heads) - 127 (41.9%) High (>40 heads) - 76 (25.1%)								
Duration of practising goat production	<5 years	303	66.5	54.8	29.9	1		-
	>5 years		33.5	45.2	70.1	3.0 (1.5-6.2)	0.003	
Provision of housing	No	303	19.5	2.8	1.1	1		-
	Yes		80.5	97.2	98.9	5.2 (1.1-24.4)	0.037	
Materials used for fencing	None	303	53.7	14.1	10.9	1		0.0008
	Bamboo		29.1	49.5	55.1	4.0 (1.4-11.7)	0.011	
	Wood		12.6	16.3	14.1	2.1 (0.7-6.1)	0.192	
	Plastic sheet		4.6	20.1	20.0	5.0 (1.7-14.5)	0.004	
Way of breeding	Own male	303	70.8	93.8	99.2	1		-
	Other male		29.2	6.2	0.8	0.1 (0.1-0.3)	0.000	
Outcome variable: Village chicken flock size Low (1-7 heads) - 115 (35.2%) Medium (8-14 heads) - 98 (30%) High (>14 heads) - 114 (34.9%)								
Provision of water	Not provided	327	28.1	21.5	14.6	1		-
	Provided		71.9	78.5	85.4	1.8 (1.0-3.3)	0.045	

Discussion

This study describes current livestock production systems in Myanmar and, importantly, identifies how different livestock enterprises interact with each other within a household. Existing studies frequently focus on a single livestock species and do not evaluate associations between livestock enterprises, and thus may miss constraints or synergies faced by households owning multiple kinds of livestock (Dreyer, Fourie et al. 1999, al-Naeem, Abu Elzein et al. 2000, Henning, Pym et al. 2007).

As in many farming systems worldwide and particularly in the developing world, our study highlights that most of the small-scale farmers in the CDZ of Myanmar keep more than one species of animal (Maass, Katunga Musale et al. 2012, Amenu, Markemann et al. 2013, LIFT 2014). Our study also demonstrates that raising of village chickens in combination with cattle or small ruminants was more common than the combination of small and large ruminants, probably because chickens are managed easily, and do not compete for ruminant resources. Although we do not ask the reason of practicing, nonetheless multispecies rearing may also have a number of benefits such as reducing economic risk associated with keeping single livestock enterprise and supporting other agricultural enterprises such as draught power for cultivating and land preparation *(Devendra and Thomas 2002).* In addition, optimizing the use of husbandry resources such as sharing animal housing, raising multiple livestock livestock species such as raising village chicken with other livestock species is likely to spread of the usage of scarce resources. However, raising multispecies will be challenging because farmers might not have finances and time to raise multiple species in their farm, in particular poorer or smaller households with limited resources.

Our finding suggested that the awareness on proper husbandry and management practice for each livestock species and multispecies rearing seem to be poor in local livestock farmers. These might be major issue to improve productivity in livestock enterprises of CDZ. We noted that the management practice were not differed among different singly species farms and multispecies farms in CDZ and farmers. This might be either due to lack of knowledge on efficient integrated farming practice with better productivity or they do not have the resources and time to raise additional livestock species within the same household in different ways.

One interesting finding from our study is that there was no significant changes in herd size in the cattle farmers and village chicken farmers with more experience of farmers on raising these animals whereas the dramatic expanding small ruminant herd size was seen in farmers with more experience. One explanation might be the majority of the farmers raised cattle for supporting other income source (such as cropping) and chicken for source of protein source for household and the expanding of herd size for direct income such as sale might not be a major concern. On the other hand, small ruminant were mainly raised for direct income source and farmers might aware of the benefit of raising small ruminant due to increasing market demand.

In cattle production, larger herds were more likely to practice grazing. A number of studies have shown that additional time and labour is required to build larger livestock enterprises (Morand-Fehr and Boyazoglu 1999, Kristjanson, Krishna et al. 2004, Budisatria, Udo et al. 2007) and our findings are consistent with these studies. The provision of freshly cut grass and potentially also supplementary feed is expensive for farmers and therefore owners of larger cattle herds prefer the practice of grazing cattle. The use of additional labour might be a challenge for cattle farmers as labour migration and therefore decreased labour availability has been highlighted as considerable constrain to livestock production in the CDZ (Kempel 2013, Phyo, Grünbühel et al. 2016).

In small ruminant enterprises, despite their potentially similar nutritional management requirements, such as grazing. Where cattle were used for draught power for crop production, farmers were more likely to actively manage animal nutrition, such as providing supplementary or full feeding to cattle at home. This practice was observed despite the likely benefits of actively managing nutrition of animals destined for sale, where improved live weights or condition would presumably increase sale income. However, our findings also indicate that shelters were more likely to be provided to larger small ruminants herds. This could be due to the fact that small ruminants kept in larger numbers need to managed and controlled more efficiently as larger flocks represent a substantial monetary value.

Even under the harsh weather condition with limited feed availability in CDZ, drinking water and scavenging feed were seem to be provided only in larger village chicken flock. Even though the reason is not clear, one possible reason might be the fact that in the majority of households with small flock size, village chicken were kept for home consumption and small income “pocket money” and it is not important source of household income. Thus, conducting proper management by providing proper feed and water in village chicken enterprise might seem to be neglected in CDZ especially in smaller flocks. Our study highlighted the investment into supplementary feed is probably only justified when larger flocks are kept under semi-intensive farm conditions (Henning, Pym et al. 2007, Henning, Morton et al. 2008, Henning, Morton et al. 2013).

Our results showed that while in cattle farms outbreeding was common, inbreeding was highly reported in small ruminant production. We expect inbreeding practices in the CDZ might be another constraint to small ruminant production in light of a number of studies reporting poor performance and production associated with the practice of inbreeding (Hermas, Young et al. 1987, Fahmy and Shrestha 2000, Muasya, Githinji et al. 2006). However, the effect of inbreeding practices on production, including impacts of inbreeding on body condition score, breeding performance and farmers’ reasons for this practice in the CDZ are still not clear and need to be investigated. Our study showed that the small ruminant farmers in CDZ seem to be not aware of benefit of not outbreeding. This might be explained by the fact that the poor animal performance due to inbreeding might not be important for value of the animals at sales. On the other hand, using males from outside the household herd were much more commonly used in cattle enterprises. One interesting question in livestock breeding practice of CDZ is if the cattle farmers aware of the benefit of outbreeding than small ruminant farmers. Providing an example on the benefit of outbreeding from might be able to bring an opportunity to improve small ruminant breeding practices. Nonetheless, the majority of cattle farmers castrate their animals at a later age (above 12 months old) using traditional castration methods which was not using proper medical care. In this situation, the welfare and safety need to be considered for both animal and human for developing better breeding management practice in CDZ.

Our study identifies current livestock husbandry practice in the CDZ of Myanmar. However, there were a number of limitation in our study. Firstly, being the data collection was based on two year period, memory recall bias which might affect on precise data availability. Secondly, even thought non-response rate is lower than 30% of the total interviewees, some important information might lose due to not available information. Thirdly, the herd or flock size and purpose of rearing was collected based on one time data collection and we might not able to identify the seasonal variation on these issues. Fourthly, even though there might be some confounders affecting our data analysis, we might face with this issue due to lack of information. Furthermore, our study mainly focused on widely-raised farm animals in CDZ, namely cattle, small ruminants and village chickens, rather than less common livestock such as pigs and ducks (FAO 2011).

Conclusions

Our study has shown that multispecies rearing by households is common in Myanmar's CDZ and species-specific husbandry practices are implemented by farmers to reduce nutritional and health stresses. Although some practices that are beneficial for one livestock species (e.g. supply of supplementary feed, provision of shelters and outbreeding) are seldom applied to other species within the same household, despite the benefits these would likely bring. This highlights the need to evaluate the household's entire livestock production 'system' and that extension training should follow a 'holistic approach' including all livestock species raised in a household.

Acknowledgement

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Statement of human and animal right

This study was followed the procedure in accordance with the ethnical standard of the institute. Ethics approval for this research was provided by the University of Queensland, Australia, Human Research Ethics Committee (approval number #2014001425).

Conflict of interest statement

The authors declare that there is no conflict of interest.

Abbreviations

CDZ: Central Dry Zone

UQ: The University of Queensland

FMD: Foot and Mouth Disease

ND: Newcastle Disease

ACIAR: Australian Center for International Agriculture Research

LBVD: Livestock Breeding and Veterinary Department

PSUs: Primary sampling units

SSUs: Secondary sampling units

VCE: Variance estimation

FPC: Finite population correction

mm: Millimetre

IQR: Interquartile rate

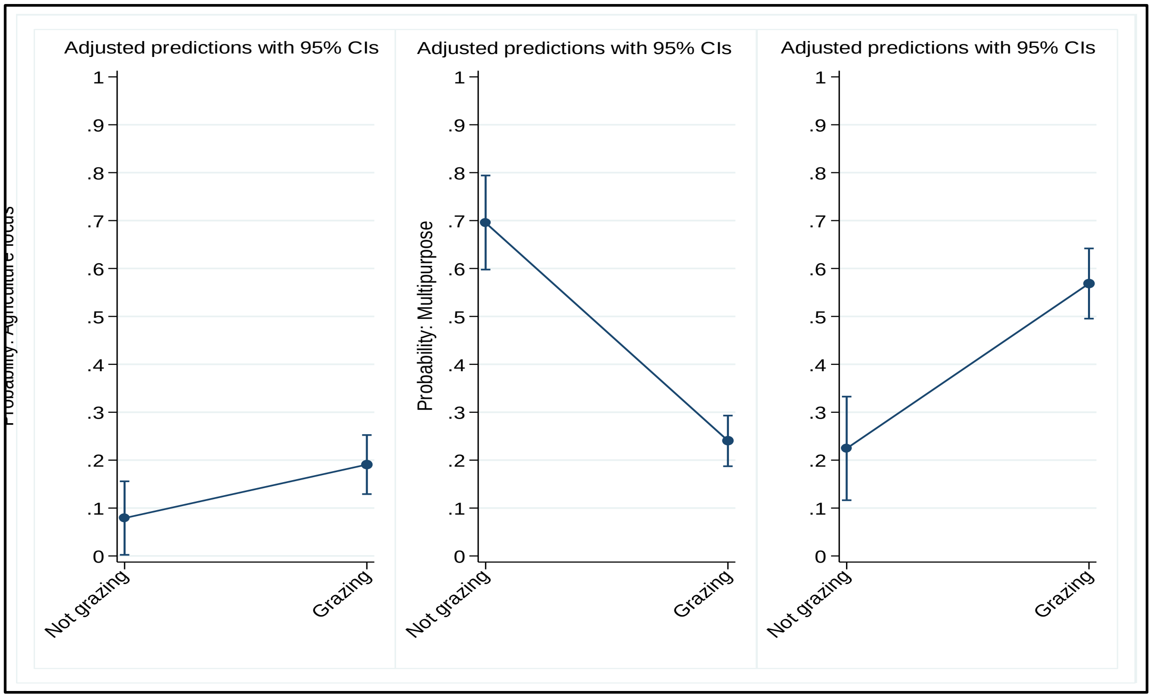
μ: Mean value

CI: Confident interval

HH: Household

AI: Artificial insemination

Supplementary Materials



Supplementary figure 1 Predicted probabilities and 95% confidence intervals for practicing grazing

Supplementary table 1 Duration of experience of farmers on livestock species in the Central Dry Zone of Myanmar

Species	Total number (N)	Proportion of farmers (Percentage with 95% CI)		
		<5 years	5-10 years	>10 years
Cattle	382	9.2 (6.4-13.2)	12.2 (8.1-18.0)	78.6 (72.8-83.4)
Sheep	303	87.2 (77.9-92.9)	5.2 (2.4-10.9)	7.7 (4.1-13.9)
Goats	303	51.2 (43.1-59.2)	19.6 (14.5-25.9)	29.3 (22.0-37.7)
Village chickens	327	23.9 (17.8-31.2)	10.6 (6.8-16.3)	65.5 (57.8-72.4)

Supplementary table 2 Characteristics of shelters provided to different livestock species in the Central Dry Zone of Myanmar

Name of variables	Categories	Cattle		Small ruminants		Village chickens	
		N	Proportion with 95% CI	N	Proportion with 95% CI	N	Proportion with 95% CI
Provision of shelters	Yes	382	82.2 (77.5-86.1)	303	93.0 (89.2-95.5)	327	12.8 (9.4-17.2)
	No		17.8 (13.9-22.5)		7.0 (4.5-10.8)		87.2 (82.8-90.6)
Materials used for roof of shelters	Not provided	382	16.4 (12.1-21.8)	303	6.4 (3.9-10.2)	327	N/A
	Corrugated metal		31.0 (22.5-40.9)		16.1 (10.3-24.1)		
	Thatch leaves		45.8 (37.6-54.4)		59.2 (49.9-68.0)		
	Plastic sheet		6.8 (3.6-12.6)		18.3 (10.7-29.6)		
Materials used for construct of fencing	No	382	88.2 (84.0-91.4)	303	24.3 (18.4-31.5)	327	N/A
	Bamboo		4.8 (2.9-7.9)		45.3 (35.5-55.6)		
	Wood		1.1 (0.3-3.6)		14.7 (8.1-24.9)		
	Plastic sheet		5.9 (3.8-9.0)		15.7 (11.0-22.0)		
Location where livestock is kept overnight	Separate building	382	77.5 (70.3-83.3)	303	86.8 (81.3-90.9)	327	1.7 (0.7-4.4)
	Tied on the tree		12.4 (8.8-17.3)		2.0 (0.6-6.9)		N/A
	Under the farm house		4.9 (2.8-8.5)		7.3 (4.4-11.9)		2.5 (1.1-5.5)
	Extension of the house		4.6 (2.2-9.3)		2.5 (1.0-6.2)		2.4 (1.0-5.9)
	Tethered in the grazing areas		0.6 (0.1-2.8)		1.1 (0.4-3.5)		N/A
	Resting in trees		N/A		N/A		68.2 (61.1-74.5)
	Sitting on the ground		0.0		0.3 (0.0-1.5)		15.5 (11.4-20.7)
	Sitting under a bamboo coop		N/A		N/A		9.7 (7.1-13.0)

Supplementary table 3 Univariate association between management practices and different herd/flock size owning cattle, small ruminant or village chicken

Variables	Categories	N	Herd/Flock size (%)			OR	p-value	Wald test
			Low	Medium	High			
Outcome variable: Cattle herd size Low (1-3 heads) - 156 (40.9%) Medium (4-6 heads) - 130 (34.0%) High (>6 heads) - 96 (25.1%)								
Hire labour	No	382	91.0	83.7	76.0	1		-
	Yes		9.0	16.3	24.0	2.4 (1.3-4.4)	0.009	
Practice grazing	No	382	39.7	21.1	1.3	1		-
	Yes		60.3	78.9	98.7	5.5 (3.1-9.8)	<0.0001	
Outcome variable: Small ruminant herd size Low (1-20 heads) - 100 (33%) Medium (21-40 heads) - 127 (41.9%) High (>40 heads) - 76 (25.1%)								
Duration of practicing goat production	<5 years	303	66.5	54.8	29.9	1		-
	>5 years		33.5	45.2	70.1	2.9 (1.5-5.4)	0.002	
Provision of housing	No	303	19.5	2.8	1.1	1		-
	Yes		80.5	97.2	98.9	11.2 (3.9-32.3)	<0.0001	
Materials used for fencing	None	303	53.7	14.1	10.9	1		<0.0001
	Bamboo		29.1	49.5	55.1	6.6 (3.1-14.3)	<0.0001	
	Wood		12.6	16.3	14.1	4.7 (2.0-11.1)	0.001	
	Plastic sheet		4.6	20.1	20.0	8.6 (3.8-19.4)	<0.0001	
Place of housing	Share the same shelter with farmers	303	17.6	8.7	3.6	1		0.0156
	Separate building		78.1	89.4	96.4	3.2 (1.5-7.1)	0.004	
	Tethering		4.3	1.9	0.0	0.7 (0.2-1.8)	0.403	
Way of breeding	Own male	272	70.8	93.8	99.2	1		-
	Other male		29.2	6.2	0.8	0.1 (0.0-0.3)	<0.0001	
Outcome variable: Village chicken flock size Low (1-7 heads) - 115 (35.2%) Medium (8-14 heads) - 98 (30%) High (>14 heads) - 114 (34.9%)								
Provision of water	Not provided	327	28.1	21.5	14.6	1		-
	Provided		71.9	78.5	85.4	1.8 (1.0-3.3)	0.045	

Supplementary table 4 Univariate association between management practices and different purpose of raising livestock

Variables	Categories	N	Agriculture focus	Cash commodity			Multipurpose			
			%*	%*	RRR	p-value	%*	RRR	p-value	Wald test
Outcome variable: Purpose of rearing in cattle production Cash commodity - 52 (15.7%) Agriculture focus - 111 (33.5%) Multipurpose - 168 (50.8%**)**										
Main income source	Cropping	318	63.5	16.8	1		54.3	1		0.0037
	Livestock production		14.7	38.7	10.0 (3.2-31.1)	<0.0001	18.1	1.5 (0.6-3.3)	0.368	
	Labour		6.3	26.1	15.7 (3.7-66.8)	<0.0001	10.6	2.0 (0.8-4.7)	0.122	
	Shop owner		1.0	6.7	24.8 (4.8-129.6)	<0.0001	5.1	5.9 (1.1-32.5)	0.043	
	Supported by relatives		14.6	11.7	3.0 (1.0-9.7)	0.062	11.93	1.0 (0.4-2.3)	0.905	
Providing of housing	No	331	9.3	38.4	1		12.8	1		-
	Yes		90.7	61.6	0.2 (0.1-0.5)	0.002	87.2	0.7 (0.2-2.2)	0.530	
Materials used for roof of housing	Not provided	331	6.3	38.4	1		11.8	1		0.0046
	Corrugated metal		34.3	21.3	0.1 (0.0-0.3)	<0.0001	37.1	0.6 (0.2-1.9)	0.352	
	Thatch leaves		49.9	32.5	0.1 (0.0-0.4)	0.001	44.8	0.5 (0.2-1.5)	0.197	
	Plastic sheet		9.4	7.8	0.1 (0.0-0.8)	0.026	6.4	0.4 (0.1-1.7)	0.195	
Practice grazing	No	331	43.4	1.7	1		4.7	1		-
	Yes		56.6	15.1	6.9 (2.2-22.3)	0.002	44.9	7.3 (3.6-15.0)	<0.0001	
Provision of supplementary feed	No	331	7.0	49.1	1		10.4	1		-
	Yes		93.0	51.0	0.1 (0.02-0.3)	<0.0001	89.6	0.7 (0.3-1.5)	0.301	
Practice castration	Not practice	331	23.5	88.9	1		34.7	1		-
	Practice		76.5	11.1	0.0 (0.0-0.1)	<0.0001	65.3	0.6 (0.3-1.4)	0.206	
Cattle herd size	Low	331	57.7	56.9	1		22.1	1		<0.0001
	Medium		32.8	21.1	0.7 (0.3-1.4)	0.270	37.0	2.9 (1.7-5.1)	<0.0001	
	High		9.6	22.1	2.3 (0.6-9.4)	0.223	40.9	11.1 (3.7-33.5)	<0.0001	

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