Poultry production, marketing, and consumption in Myanmar: A review of literature

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Abbreviations and acronyms

ACIAR	Australian Centre for International Agricultural Research
ADS	Agriculture development strategy
ASTI	Agricultural Science and Technology Indicators
CP	Charoen Pokphand
CSO	Central Statistical Organization
DOCs	Day-old chicks
FAO	Food and Agriculture Organization of the United Nations
FTE	Full-time equivalent
GDP	Gross domestic product
HDDS	Household diet diversity score
IFC	International Finance Corporation
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
JICA	Japan International Cooperation Agency
LBVD	Livestock Breeding and Veterinary Department
LIFT	Livelihood and Food Security Fund
MOALI	Ministry of Agriculture, Livestock and Irrigation
MOECF	Ministry of Environmental Conservation and Forestry
MOHS	Ministry of Health and Sport
NCC	National consultative committee
NCDP	National comprehensive development plan
SAPA	Sustainable and affordable poultry for all
UNICEF	United Nations Children's Fund
WHO	World Health Organization

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Executive summary

An Australian Centre for International Agricultural Research (ACIAR)-funded project called 'Asian Chicken Genetic Gains (AsCGG): a platform for exploring, testing and delivering improved chickens for enhanced livelihood outcomes in Southeast Asia' has been implemented by International Livestock Research Institute (ILRI). This project covers Cambodia, Myanmar and Vietnam. The project aims to test and avail high-producing and farmer-preferred chicken genotypes to increase smallholder chicken production and productivity as a pathway out of poverty in the three countries. The project starts with a comprehensive literature review to document the current knowledge base, identify research and development gaps and inform a baseline assessment. This document presents the main findings of the literature review in Myanmar. The review synthesizes evidence on smallholder poultry production and productivity, poultry products marketing; contribution of smallholder poultry production to household nutrition; economic contribution of smallholder poultry production, agricultural policy and livestock research and finally, a conclusion and research opportunities.

Most of the agricultural households in Myanmar engage in poultry production. Poultry production is the most considerable livestock production activity in the country. The poultry raised comprises different species such as chicken, duck, turkey, geese and Muscovy duck. From 2009 to 2018, chicken and ducks accounted for 91.3% and 7.7% of the total poultry population in the country and only the remaining 1% accounted for other species. During 2017/18, there were about 322.04 million chickens and 25.45 million ducks in the country, respectively. The indigenous chicken accounted for 87.7% of the chicken population. The overall poultry population grew by 10.9% from 2009 to 2018.

Poultry production is the major contributor to meat consumed in the country. From 2009 to 2018, on average, the poultry sector contributed 55.6% of the total meat produced by the livestock sector. The total poultry meat produced grew by 8.1% per year in this period. The average contributions of poultry meat produced from chicken, duck and other poultry species were 90.9%, 8.5% and 0.6% per year, respectively.

There was an increasing trend in the number of eggs produced in the country. During 2009-18, the total amount of chicken and duck eggs produced grew by 8.3% and 7.9% per year, respectively. While chicken egg accounted for 91.3% of the total egg produced, duck egg accounted for the remaining 8.7%.

The increase in production has increased consumption. From 2000 to 2018, the average consumption of poultry meat and egg grew by 10.2% and 9.9% per year, respectively. In 2018, the average poultry meat consumption was 29.1 kg/capita/year, while the average egg consumption was 9.47 kg/capita/year.

There was significant spatial variability in poultry production among different regions. In 2018, the highest population of local chicken producers were found in Ayeyarwady (17.05%), followed by Bago (13.34%), Shan (11.93%), Sagaing (10.47%) and Magway (10.26%) regions and these five regions accounted for about 63.05% of the overall local chicken producers in the country.

Similarly, the highest proportions of commercial chicken producers (broilers & layers) were found in Rakhine (15.02%), Mandalay (14.75%), Ayeyarwady (14.41%), Sagaing (13.41%) and Yangon (10.81%) regions/states. The variability in the intensity of production could be associated with grain production such as rice, access to the market and other environmental and infrastructural issues.

In Myanmar, the poultry production system can be classified into traditional/backyard production, semi-intensive small/medium production and intensive medium/large scale industrial production. The traditional/backyard production is an indigenous breeds-based low-input low-output production system that accounts for more than 80.0% of the poultry production in the country. A semi-intensive small/medium production system is considered a transition from the traditional/backyard production to an intensive medium/large scale industrial production system. Producers use improved or indigenous breeds with better management practices in this system. The intensive production system has a very recent history in Myanmar and it needs high initial investment costs to establish infrastructures. This system adopts advanced management practices such as better health and biosecurity and improved feeding and housing systems.

Myanmar has different indigenous strains mainly used under traditional/backyard production and semi-intensive small/medium production systems such as Taik Kyet, Tainnyin Kyet, Kyet Lada, Sittagaung, Inbyinwa Kyet and Hle Pyiang. The productivity of traditional/backyard smallholder chicken production is generally considered low. This could be associated with the limited genetic potential of indigenous breeds, inadequate husbandry practices, limited access to affordable and quality feeds, higher disease incidence and mortality, limited capacity of producers and unfavourable environmental conditions. On average, an indigenous breeds hen lays 12 eggs per clutch with three clutches per year. The eggs from indigenous breeds are usually used for chick production or brooding and the mortality of chicks is a major challenge. The average body weight of adult male and female indigenous chickens is 1.65±0.61 kg and 1.49±0.63 kg, respectively.

The marketing of poultry products is an integral part of traditional/backyard and semi-intensive/intensive production systems. Most smallholder chicken producers participate in marketing live birds and eggs directly to consumers or collectors in the village and local markets. In the smallholder poultry production system, collectors play an important role in marketing live birds and eggs. Unlike traditional/backyards producers, semi-intensive or intensive producers have well-established marketing chains. Moreover, some of the available intensive commercial farms are highly integrated with well-established input supply and marketing chains.

Local consumers have a higher preference for indigenous chicken products than exotic chicken products. As a result, indigenous chicken eggs and meat fetch a higher price than exotic chicken meat and egg. This could be is an excellent incentive to sustain the indigenous chicken species in the country.

Under the smallholder production system, poultry products marketing has different constraints. The major constraints include inadequate indigenous products supply, price fluctuation, inadequate marketing infrastructures, disease, limited access to markets, mortality of birds, weight loss during transportation, limited food safety and hygiene and limited access to processing facilities.

Undernutrition is the major health and development constraint in Myanmar and other Southeast Asian countries. Although undernutrition in Myanmar looks suboptimal, there is significant variability among regions and household wealth groups. Households in the lower wealth quintiles and some regions have lower dietary diversity and higher stunted children than households in other regions and higher wealth quantile groups. The lower diet diversity and undernutrition could be associated with over-consumption of staples such as rice and under-consume all non-staple food groups, including poultry products.

Enhancing the production and productivity of smallholder poultry production would significantly contribute to household diet diversity and nutrition security. This would be achieved through different pathways such as increased production for own consumption, increased household income to purchase other food items and women empowerment. Poultry meat and eggs supply cheap protein, vitamins, minerals and other essential nutrients.

Poultry production has multiple economic contributions to smallholder producers, mainly resource-poor and landless households. Besides generating additional income, enhancing the production and productivity of the sector has a substantial contribution to food security and poverty reduction, as landless and near-landless households can adopt it. Moreover, its lower production cycle and low input requirement make it suitable for entry points in poverty reduction strategies and improve households' resilience during household shocks.

The multidimensional contribution of agriculture to the overall economy and the existing production and productivity gap makes improving the production and productivity of the agricultural sector at the centre of most development policies and strategies in Myanmar. Research and extension activities have been integral to most agricultural development policies and strategies. However, research activities have been underfunded and biased toward crop research than livestock research. The attention given to livestock research was inadequate and previous research mainly focused on veterinary medicine, animal nutrition and management aspects. Studies on animal breeding/genetics look negligible. Like other livestock species, the research and development effort in the poultry sector was inadequate as most of the previous and existing research efforts focused on improved feed, health and management options.

Poultry production and productivity at the smallholder level remain low due to the limited genetic potential of indigenous breeds, inadequate husbandry practices, higher disease prevalence, bird mortality, inadequate inputs access and delivery system and other marketing-related constraints. Approaches to address various constraints need to adopt integrated research and development efforts. This may include developing innovations that enhance the production and productivity of existing breeds; building the capacity various value chain actors; establishing a public-private partnership for effective input delivery and output marketing; and improving the overall performance and competitiveness of the value chain. Research and development efforts to improve the production and productivity of existing breeds may adopt the following approaches. Improving the genetic potential of existing breeds, introducing locally adapted and farmer-preferred improved breeds and developing innovative and context-specific management practices that enhance the competitiveness and efficiency of different production systems.

1

Introduction

Agriculture plays an important role in the economy of Myanmar and it includes crop, livestock, fisheries and agro-forestry production. The agricultural sector has a substantial contribution to GDP, employment and export earnings. In 2017/18, at the end of March, the share of agriculture to the GDP was 23.3% (MOPF 2019b). According to WB (2021), in 2018, the share of employment in the agricultural sector was 48.17%. Livestock production plays a significant role and the share of livestock and fishery to the GDP was about 7.8% in 2017/18 (MOPF 2019b). The livestock production sector includes cattle, buffalo, sheep and goats, pigs and poultry. Poultry production is the largest livestock production activity in the country and it comprises different species such as chicken, duck, turkey, geese and muscovy duck. Despite its substantial contribution, the agricultural sector in Myanmar is characterized by low productivity and underfunded research and extension supports (MOALI 2018).

The poultry production sector consists of traditional/backyard production, semi-intensive small/medium production and intensive medium/large scale industrial production systems. However, the traditional/backyard production system is the dominant production system in the country. According to Henning and Pym (2019), about 80% of the chicken is produced by smallholder farmers through the traditional/backyard or semi-intensive production system. This production system has a significant contribution to the livelihood of most rural and urban households. It is the source of cheap protein and income to most resource-poor rural and peri-urban households. Unlike traditional/backyard production, the number and distribution of intensive commercial poultry farms are extremely limited.

Demand for poultry products has shown a significant increase in the previous few years and is projected to show a substantial increase in the coming few decades (ICEM 2014). However, the overall production and productivity of the sector have remained low during the previous few decades. This calls the attention of government and non-governmental organizations for research and development interventions that would address existing production and marketing bottlenecks. As a result, International Livestock Research Institute has initiated a Research for Development Project (R4D) that aims to contribute to the transformation of smallholder chicken production and productivity in the country.

The proposed project starts with a comprehensive literature review to understand the current knowledge base and identify research and development gaps. The review will also inform a baseline assessment that aims to quantify current smallholder chicken production and productivity, husbandry practices, producers' preference, consumer demands and socio-economic status of poor smallholder farmers in the country. Therefore, we conducted a comprehensive literature review and synthesized evidence on poultry production and marketing activity, consumption of poultry products, nutritional and economic contribution of poultry production and research and development effort in the country.

The review mainly focuses on the smallholder poultry production and marketing activities and comprises the following sections. Firstly, the review outlines trends in overall poultry production and consumption. Then it explores existing practices in smallholder chicken production and productivity followed by poultry marketing activities and the country's nutritional and economic contribution of smallholder chicken production. Subsequently, the review highlights agricultural policy and livestock research and, finally, a conclusion and research opportunities.

2

Review approach and data sources

We adopted a scoping review approach as the review's aims to explore and summarize available evidence and inform the proposed research activities in the country (Peterson et al. 2017; JBI 2020). This approach helps us generate evidence in broader topics related to poultry production, marketing, consumption in the country and identify research and development gaps (Pham et al. 2014). We synthesized evidence from diverse sources such as published articles, unpublished works, national and international databases and policy documents. We used time-series data from different sources such as the Ministry of Planning and Finance (MOPF), Food and Agriculture Organization of the United Nations (FAO) and International Trade Centre (ITC.) to examine trends in production, consumption and other related indicators. Empirical evidence on poultry production, marketing and consumption was also synthesized at the household and national levels from diverse sources. Moreover, policy and development evidence were elicited from policy documents and books to define concepts and explain issues.

3

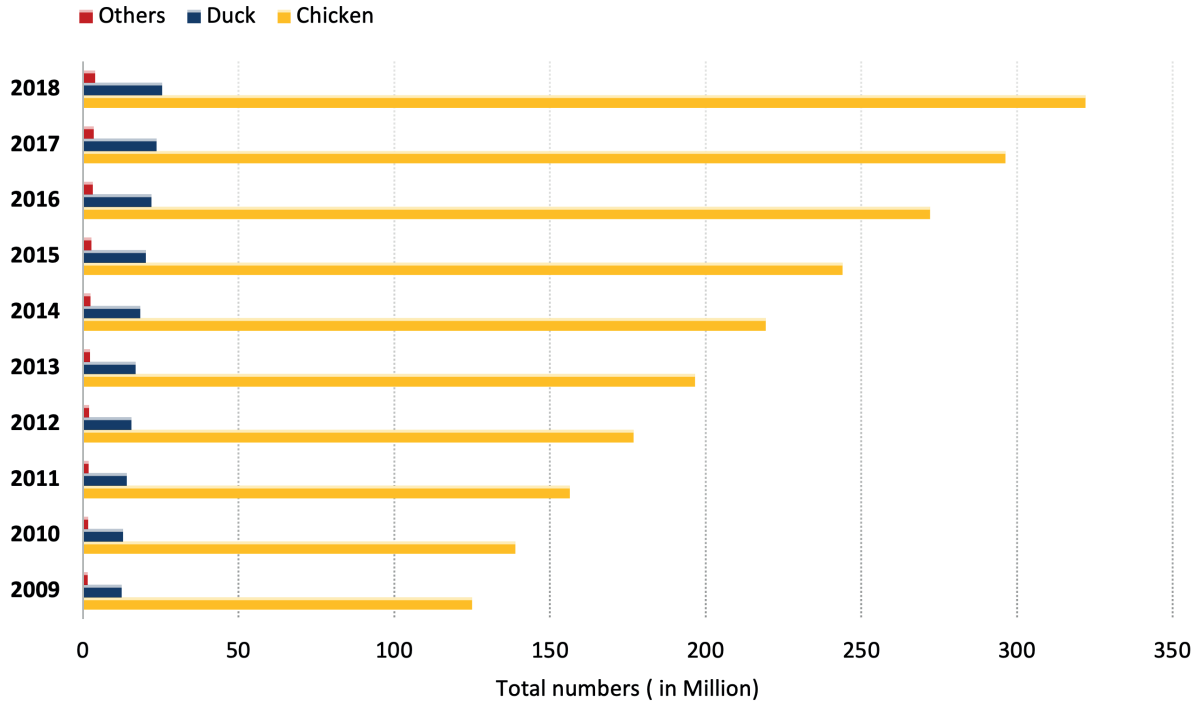
Overview of poultry production and consumption

3.1 Total poultry population and growth trend

Poultry is the most common livestock species kept by the majority of the agricultural households in Myanmar. Poultry production is usually an integral part of other livestock and crop production activities such as fish and rice production. The poultry species include indigenous/native chickens, broiler (meat breed) chickens, semi-broiler chickens, egg layer chickens, ducks, turkeys, geese and quail (LBVD 2019). From 2009 to 2018, on average, chicken accounted for 91.3% of the poultry population, followed by ducks (7.7%) (Figure 1). Other species (turkeys, geese and quail) accounted for only 1% of the poultry population. Each poultry species includes indigenous/native and exotic species used for meat and egg production. However, the indigenous species account for the largest proportion of all species. For instance, among the total chicken population, 87.7% accounted for indigenous chicken (MOALI and JICA 2018). In 2017/18, there were about 322.04 and 25.45 million chickens and ducks in the country, respectively. The average number of indigenous chickens per holding was 12, with a minimum average of 9 in Chin and Shan (North) States and a maximum average of 16 in Bago (East) and Yangon states.

There was significant growth in the total poultry population (Figure 1). For instance, from 2009 to 2018, the overall poultry population (chicken, ducks and others) grew by 10.9% per year. The average growth in chickens, ducks and other species was 11.1%, 8.4% and 10.8% per year, respectively. Haggblade et al. (2014) have documented an average annual growth of 6% during 1985/86-2009/10. The shows that the sector has been experiencing significant change in the previous three decades. The overall production growth was primarily driven by the intensive medium/large scale commercial and integrated industrial production sector. For instance, according to Belton et al. (2020), the number of integrated chicken-fish farms around Yangon doubled between 2014 and 2018 and more than 50% of sampled broiler and layer farms were established within the past five years.

Figure 1: Total number of poultry population in Myanmar expressed in million (2009-18).

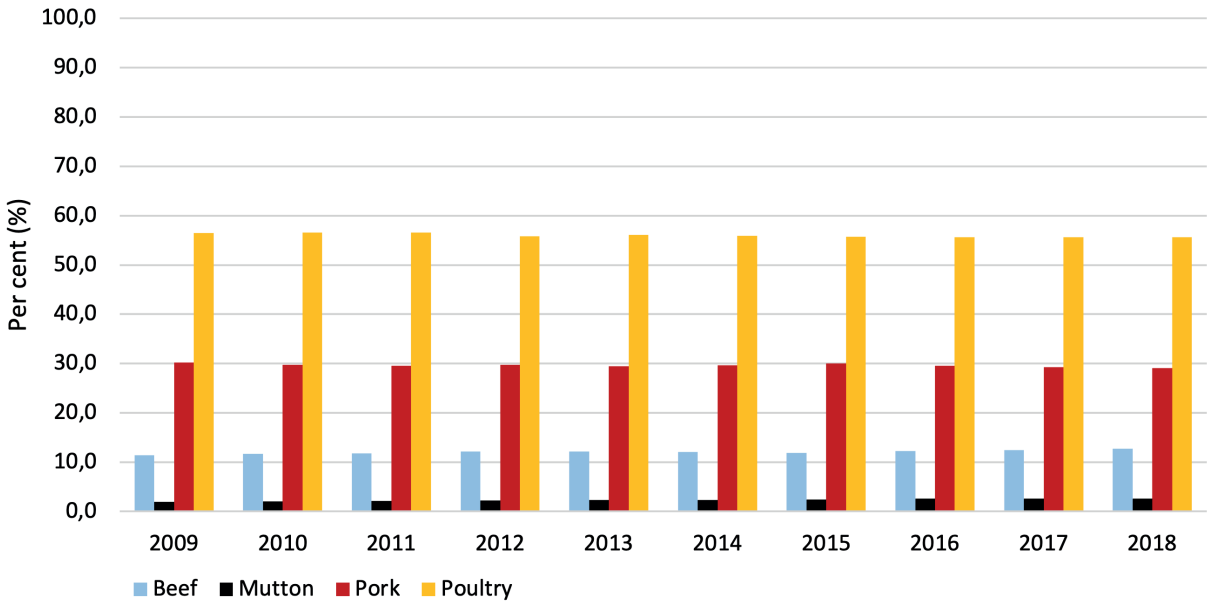


Source: Compiled by authors using data from the MOPF (2019a)

3.2 Poultry meat and egg production and growth trend

Poultry production is the major contributor to meat and eggs produced and chicken meat is called the national meat of the country (MOALI and JICA 2018). Chicken meat and egg are the most commonly available cheap protein source foods for most rural and urban households in the country (Fang et al. 2021). During 2009-20018, on average, the poultry sector contributed 55.6% of the total meat produced by the livestock sector (Figure 2). Following poultry, pig production is the second most important meat contributor and it accounts for 29.1% of the overall meat produced in the country. Cattle and sheep/goat production contributed the remaining 12.7% and 2.6% of the total meat produced, respectively. This shows the vital role of poultry production in the overall economy and the country's nutritional security. Moreover, chicken and pigs are usually slaughtered for household and commune religious and non-religious ceremonies such as wedding and hunting celebrations and ensure heritage transmission (LIFT 2019), which indicates the socio-cultural contribution of these animals beyond their economic and nutritional contributions.

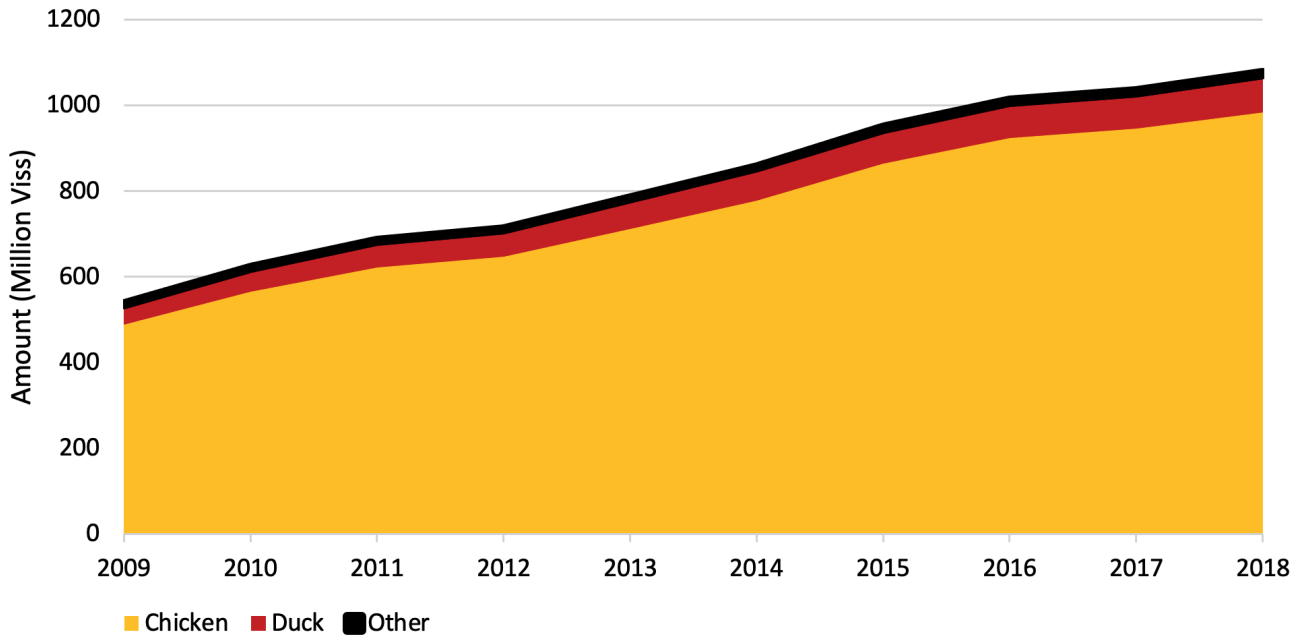
Figure 2: Proportion of meat produced by different types of livestock (2009-18).



Source: Compiled by authors using data from the MOPF (2019a)

The overall poultry meat production has also shown a significant increase from 2009 to 2018 (Figure 3). On average, the total poultry meat produced grew by 8.1% per year and chicken production was the largest contributor to the overall poultry meat produced in the country. The proportion of poultry meat produced from chicken, duck and other species was 90.9%, 8.5% and 0.6%, respectively. This indicates the vital role of chicken production in the country.

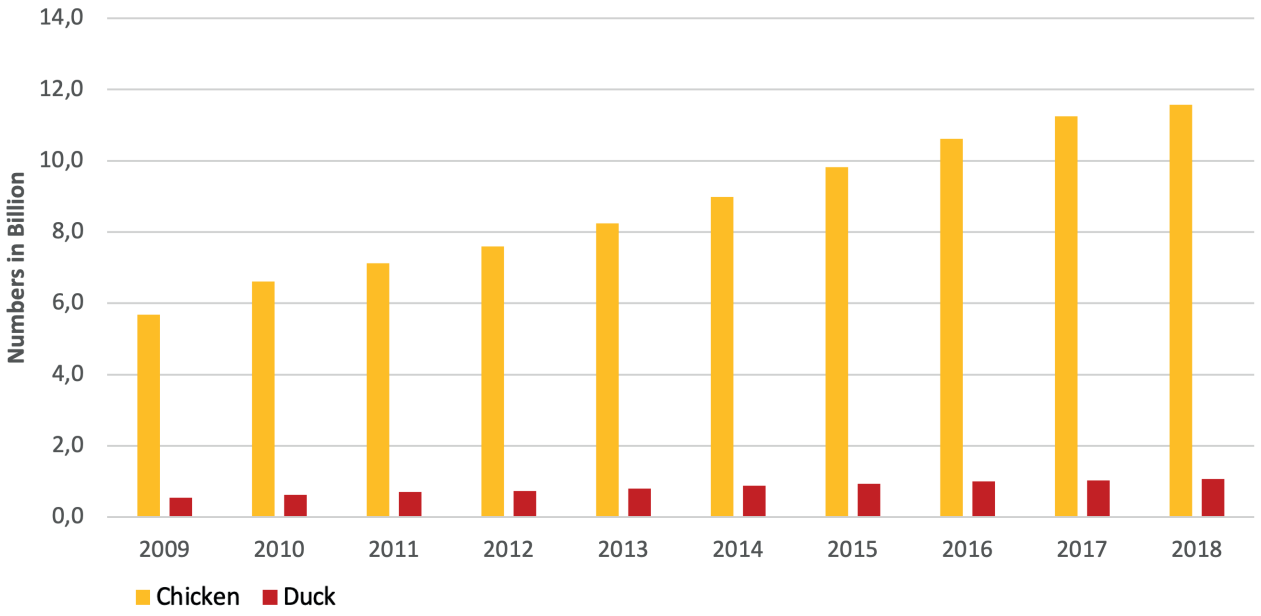
Figure 3: Poultry meat produced by different poultry species (2009-18).



Source: Compiled by authors using data from the MOPF (2019a)

Chicken and duck egg production supply a larger proportion of eggs consumed in the country. In 2018, the country produced 11.6 billion chicken and 1.1 billion duck eggs. From the total eggs produced, 91.3% was produced from chicken and the remaining 8.7% was from the duck. There is no adequate evidence on the volume of eggs produced from other poultry species. Like poultry meat, there was significant growth in the overall production of eggs from 2009 to 2018 (Figure 4). On average, the total amount of chicken and duck eggs grew by 8.3% and 7.9% per year, respectively. Chicken and duck production remains the major contributor of poultry egg and meat in the country.

Figure 4: Total number of eggs produced by poultry species (2009-18).

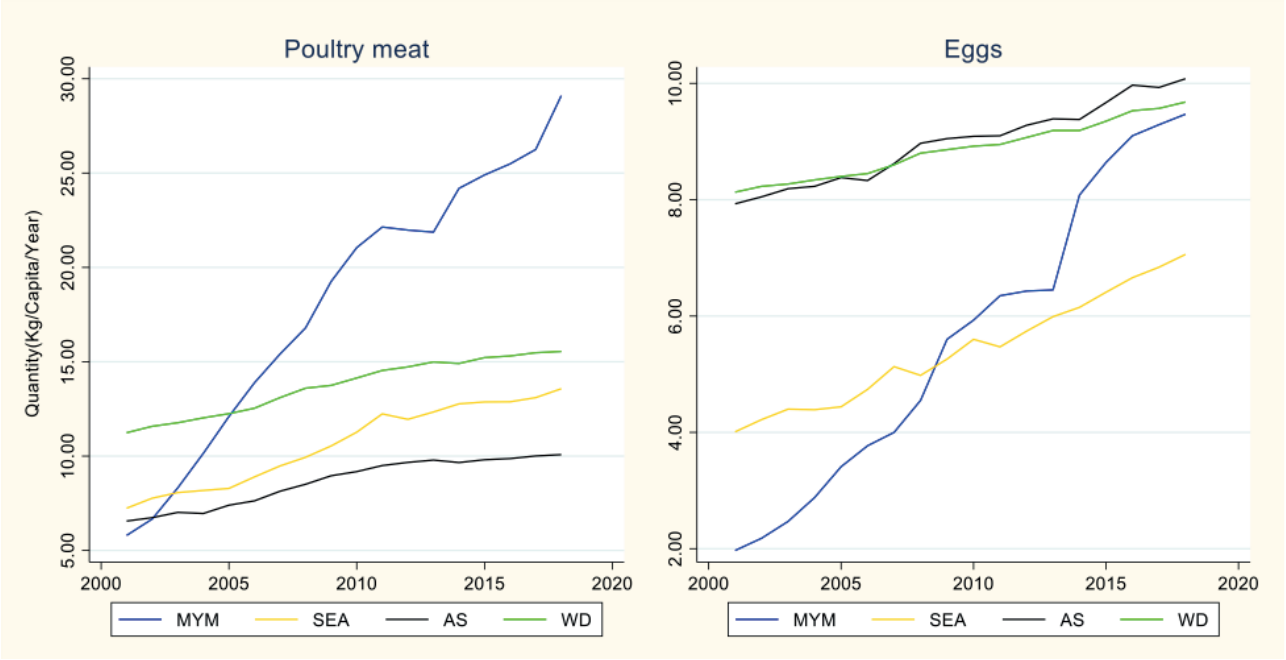


Source: Compiled by authors using data from the MOPF (2019a)

3.3 Trends in poultry meat and egg consumption

There was also a significant growth in overall meat and egg consumption from 2000 to 2018 (Figure 5). On average, poultry meat and egg's overall per capita consumption grew by 10.2% and 9.9% per year, respectively. The growth in poultry meat consumption was slightly higher than in egg consumption. In 2001, the average meat consumption was about 5.8 kg/capita/year, but in 2018, the average consumption increased to 29.1 kg/capita/year. Similarly, in 2001, the average egg consumption was about 1.97 kg/capita and this value increased to 9.47 kg/capita/year in 2018. These indicate a significant increase in the consumption of poultry products in the country. The average growth in meat and egg consumption was higher than the global, regional and sub-regional average growths. For instance, from 2001 to 2018, the average global egg and meat consumption growths were 1.03% and 1.93% per year, respectively. But despite an increasing trend in consumption, the average egg consumption has remained lower than the regional and global averages. In Myanmar, most poultry products were supplied by domestic production, although there has been some import mainly since 2013.

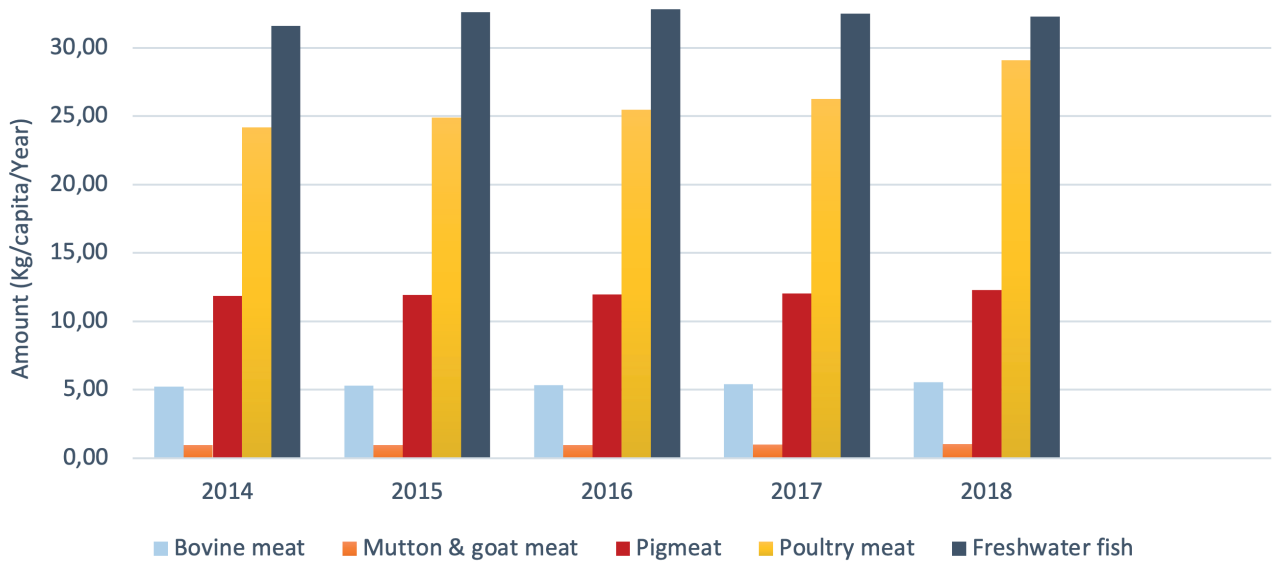
Figure 5: Average amount of poultry meat and eggs consumption (2000-17).



Source: Compiled by authors using data from FAO

Following fish, poultry meat is the most common meat consumed in Myanmar, associated with cultural-religious factors (IFC 2016). Households in the country have a higher preference for poultry meat than other livestock meat such as bovine, sheep/goat and pig meat. There was a significant increase in the consumption of poultry meat compared to the other livestock meat and fish. For instance, from 2014-18, the average increase for bovine, sheep/goat and pig meat consumption were 1.50%, 1.80%, 0.92% and 0.55% per year, respectively, while the average increase for poultry meat consumption was about 4.79% per year (Figure 6). An increasing trend in consumption of poultry meat could be associated with an increase in production and a decrease in the price of poultry products compared to other livestock products. According to Belton et al. (2020), between 2008 and 2017, while the real price of chicken meat and eggs showed a significant reduction, the real price of pork, beef and mutton showed a considerable rise. Due to an increasing middle-income population trend, demand for poultry products was predicted to grow by 10-15% per year in the country (IFC 2016).

Figure 6: Consumption of animal source meat and fish (2014-18).

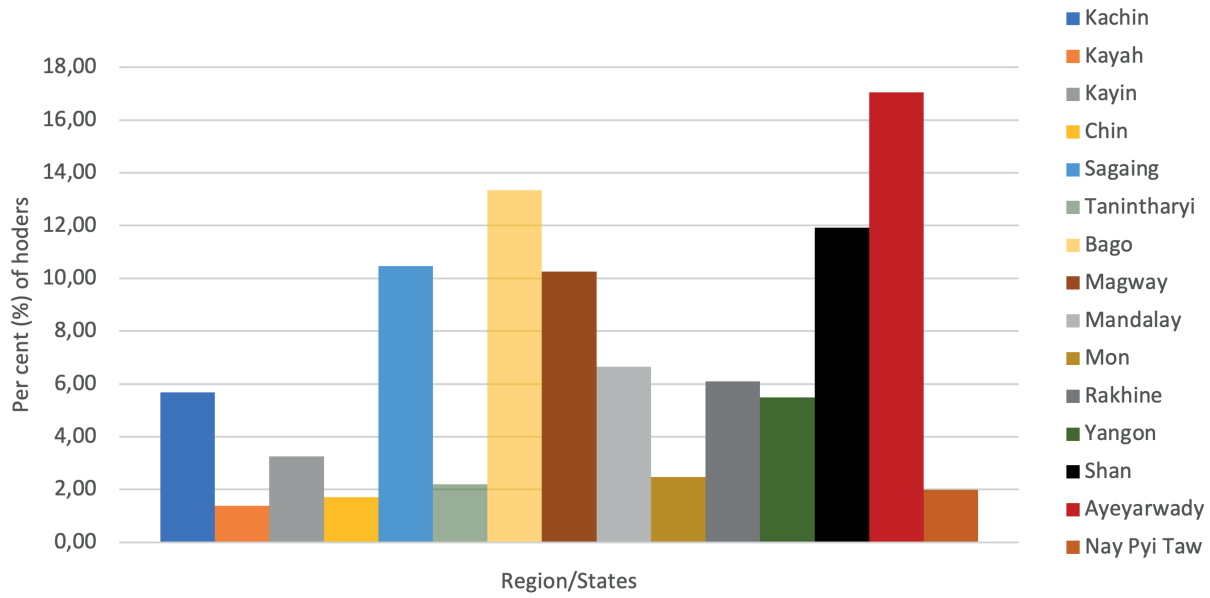


Source: Compiled by authors using data from the FAO (2021)

3.4 Geographical distribution of chicken production

Chicken production is an integral part of agricultural activities in different states/regions of Myanmar. But there is significant variability in the distribution of chicken production among different regions (Figure 7). For instance, in 2018 the livestock baseline survey, there were 3,974,696 indigenous chicken producers in the country. The highest number of indigenous chicken producers were found in Ayeyarwady (17.05%), followed by Bago (13.34%), Shan (11.93%), Sagaing (10.47%) and Magway (10.26%) regions (Figure 6). These five regions accounted for about 63.05% of the overall local chicken producers in the country. The higher number of producers in these areas could be associated with higher rice production that supplies less costly feeds to chickens and higher population density, which creates a better market for poultry products (Win 2012). The lowest number of producers was found in Kayah, followed by Chin regions/states, which contributed less than 2% of the total indigenous chicken producers.

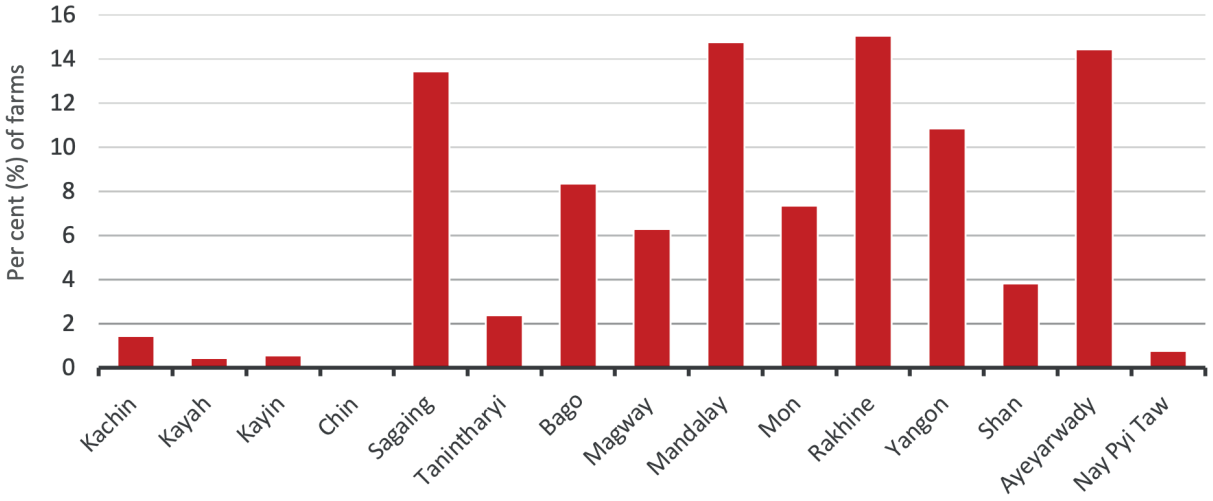
Figure 7: Geographical distribution of indigenous chicken producers in 2018.



Source: Compiled by the authors using data from the LBVD (2019)

Similarly, there were 17 055 commercial chicken farms (10,747 broilers and 6,278 layers) during the same period. A higher proportion of the commercial farms (broilers & layers) were found in Rakhine (15.02%), Mandalay (14.75%), Ayeyarwady (14.41%), Sagaing (13.41%) and Yangon (10.81%) regions/states (Figure 8). The lowest proportions of these commercial farms were found in Chin (0.06%) and Kayah (0.45%) regions/states. The commercial farms mainly keep broiler and layer chickens in the intensive production system (LBVD 2019).

Figure 8: Geographical distribution of commercial chicken farms (broiler/layers) in 2018.



Source: Compiled by the authors using data from the LBVD (2019).

3.5 Poultry meat import

Myanmar has been a net importer of poultry meats in the previous few years. Poultry meat was imported from different countries, including India, France, Brazil and Thailand. Although the proportion of imports was smaller, there was an increasing trend in the value and volume of imports in the previous few years (Table 1). For example, compared to 2015, the value of imports was increased by 336.9% in 2019. The country imported 318 tonnes of poultry meat worth USD450,000 in 2019, while 38 tonnes worth USD103,000 in 2015. An increasing trend in imports may also show the growing trend in poultry products consumption.

Table1: Value of poultry meat imported from different countries (in 1000 USD).

Origin	2015	2016	2017	2018	2019
India	0	0	0	0	139
France	0	5	14	24	93
Brazil	0	0	93	226	79
Thailand	7	28	0	49	54
New Zealand	0	0	0	0	38
Others	96	96	135	107	48
World	**103**	**129**	**243**	**406**	**450**

3.6 Poultry production systems

The poultry production system in the country comprises both traditional and commercial production systems. But like other developing countries, the poultry production system in Myanmar can be classified into three major categories: traditional/backyard production, semi-intensive small/medium scale production and intensive medium/large scale commercial production (Burgos et al. 2009). The classification is mainly based on the goal of production, type of breeds used, the scale of production, level of inputs used and production technologies adopted. As indicated above, during the previous few decades, there was a momentous increase commercial production sector

3.6.1 Traditional/backyard production

This is the dominant production system and it accounts for about 87.9% of poultry production in the country (MOALI and JICA 2018). Producers in this production system use indigenous breeds under low-input low-output village management conditions (Henning and Pym 2019). For a foundation flock, they use hen, cock and pullets/cockerels obtained either from local markets or fellow farmers. A smaller proportion of them may get from local hatcheries. For instance, according to Win (2012), 73%, 25% and 2% of the producers obtained their foundation flocks from neighbour farmers, own production and local hatcheries, respectively. Producers use indigenous breeds for egg and live bird production (Henning and Pym 2019) and they usually have smaller flock sizes from 10-40 birds (Burgos et al. 2009; LBVD 2019). The hens are the incubator and brooder of chicks. Producers mainly raise birds for income generation by selling live birds, followed by home consumption and cockfighting (Win et al. 2019). Women and children have significant roles in production and marketing activities in this system.

Scavenging is the main feed source in a traditional/backyard production system, but producers sometimes provide little supplementary feed like rice, food scraps, maize/sorghum and broken rice (Win et al. 2019). For example, Win et al. (2019) documented that 90% of the respondents let their chicken scavenge throughout the year. But some of the producers provide supplementary feed such as rice (90.0%), food scraps (48.0%), maize/sorghum (25.0%) and broken rice (10%). They also provide feed for green fodder and forage crops to enhance productivity and prevent cannibalism (Aung 2019). Producers in this system adopt poor health and biosecurity systems. Only very few use vaccination and disease treatment services and mortality of chicks and adult birds are common (Henning et al. 2006; Henning et al. 2009a; Win 2012). Unlike other livestock species, only very few producers provide housing for chicken. According to Win et al. (2019), only 12.8% of the village chicken producers provide housing, while 82.2% and 93.0% provide shelter to cattle and small ruminants. Broadly, the overall management system for chickens is considered poor. The inadequate feed, housing and health services offered usually lead to higher mortality of birds, mainly chicks.

Most traditional/backyard producers consider poultry production a side business to supply meat and eggs for households' consumption and generate additional income to support other livelihood activities (Henning et al. 2006). Poultry products produced in this system has the following potential comparative advantages (Henning and Pym 2019): fetch premium prices (about four times than broiler chickens); local consumers highly prefer them; the birds can be raised sustainably under free-range conditions. Due to an increasing demand for poultry meat, associated with better health consciousness of consumers, studies show that vaccination and improved chick management improve the survival and profitability of traditional/backyard chicken production in the country (Henning et al. 2013).

3.6.2 Semi-intensive small/medium scale production

This production system accounts for a smaller proportion of poultry production and producers keep 50 to 1,000 improved or indigenous birds (Burgos et al. 2009). The management system is better than the traditional/backyard production system, including improved biosecurity, sanitation, feeding and watering (Henning et al. 2013). Better feeding and housing systems and improved breeds are the main factors differentiating this production system from the traditional/backyard production system (Pym 2017). Both improved and indigenous poultry breeds used in this system can be kept in confined houses or as free scavenging in gardens, backyards, orchards and vacant lots (Burgos et al. 2009; Henning and Pym 2019). Replacement stock is obtained from own flocks or local hatcheries purchased as day-old chicks (DOCs). Producers sell live birds, eggs, or meat to generate income. Compared to the traditional/backyard system, this system needs higher initial investment and variable costs and it usually generates higher income for producers.

This system is considered a transition between traditional/backyard production and intensive medium/large-scale industrial production systems. Studies show that indigenous birds kept in this production system can generate higher income than birds kept in the traditional/backyard production system. For instance, Henning and Pym (2019) shows that indigenous chicken based semi-intensive production is profitable due to the premium price paid to indigenous breed products. Some farmers adopt this strategy (LBVD 2019).

This production system is considered viable for smallholder farmers in Myanmar due to the increased productivity compared to birds in the traditional/backyard production system (Win 2012; Henning and Pym 2019). However, according to Henning and Pym (2019), to enhance the viability of this production system, further research is required on breeding and genetics, housing and nutrition, quality and availability of poultry feed and marketing of birds. One of the important constraints to adopting this production system in developing countries is access to feed, especially protein source feeds. Research shows that farmers can use insects such as harvested termites as a source for protein and other nutrients such as energy, vitamins, and minerals obtained from locally available sources (Sherman et al. 2019).

3.6.3 Intensive medium/large scale industrial production

The intensive medium/large scale industrial production system has a very recent history in Myanmar. Evidence shows that introduced by a Thai company called Charoen Pokphand (CP) in the 1990s. Since then, this system has shown significant growth (IFC 2016; Belton et al. 2020). Farms under this production system can be categorized as layer, broiler and semi-broiler farms (Belton et al. 2020). Semi-broilers are farms that use male layers for meat production. The average production cycle of broilers is shorter than semi-broilers and the average marketing weight of broilers is higher than semi-broilers. The number of farms under this production system is minimal, accounting for less than one per cent of the total poultry producers in the country (LBVD 2019).

This production system needs a high initial investment cost to establish infrastructures and adopt advanced management systems such as better health and biosecurity systems and improved feeding and housing systems. Birds are fed nutritionally balanced commercial feeds and the flock's productivity is higher than the above two systems. For instance, a layer can produce 250-270 eggs per year and broilers can reach 1.75 to 2.0 kg of marketing weight at six weeks (Burgos et al. 2009). According to Win (2012), broilers can reach 2.0 – 2.4 kg from six to seven weeks and semi-broiler reach 0.9 to 1 kg within ten weeks. The higher productivity of birds in this system could be associated with genetic and management-related factors.

In these production systems, producers keep a flock size of more than 1,000 birds sourced from local or foreign commercial hatcheries (Burgos et al. 2009). As indicated above, there is significant variability in the size and distribution of farms associated with access to input and output markets. The largest proportions of broiler or semi-broiler farms were found in Ayeyarwady, Kayin Rakhine, Mandalay, Yangon and Bago (East) regions, while the largest proportion of layer farms was found in the Shan region (LBVD 2019). Based on the national baseline survey, on average, layer and broiler farms keep 2,000 and 1,500 chickens, respectively. Nonetheless, a recent study by Belton et al. (2020) shows that the average flock sizes for broiler, semi-broiler and layers farms in Yangon's peri-urban zone were 6,089, 11,910 and 13,791 chickens, respectively. The divergence in the average numbers of flock size could be associated with a difference in sample sizes and scope of the study. The study conducted by Belton et al. (2020) focused on medium mad large-scale commercial farms in regions where a higher number of broiler and layer chickens are found.

The broiler and layer farms could be integrated with fish farms. An integrated chicken-fish production system is one of the innovative poultry production systems practised by commercial producers in different country areas. Producers built chicken houses above or beside fishponds to use chicken waste as inputs for fish production. Due to the multiple benefits of integrated farms, there was significant growth in the number and spatial distribution of integrated chicken-fish farms during 2014–18 (Belton et al. 2020). The multiple benefits may include socio-economic and environmental contributions such as reducing the feed cost of fish, reducing manure accumulation and unpleasant odours around the farms, maximizing land utilization and reducing risks associated with poultry production due to additional income gains from fish production (Belton et al. 2020). Usually, the integrated farms have a larger size than the non-integrated farms.

In the intensive production system, poultry farms are operated mainly by households and individuals (94%) and very few of them are managed through partnerships or companies (Belton et al. 2020). Some of the existing companies are vertically integrated, working on input supply, production, processing and marketing of outputs (IFC 2020). For instance, CP Myanmar is an integrated company with a 40-45% market share. This company integrates four feed mills (Yangon, Mandalay, Kyaut Me and Taung Gyi); breeder farms in different locations (Breeder farms: Bago, Ye' Mon, Thar Yar Gone, Inta Gaw and Sint Kine); hatcheries (Hatcheries: Yangon and Mandalay); and one in Yangon with a capacity of 1.500 birds/hour (Larive-International 2015; IFC 2016). Similarly, Japfa Maykha is a vertically integrated farm with a 20-25% market share. This company integrates two poultry feed mills (Yangon and Mandalay); broiler and layer breeding farms, hatcheries and commercial broiler farms in different locations (Yangon, Mawlamyine, Pyay, Pakokku, Nay Pyi Taw, Meiktila and Mandalay) (Larive-International 2015). Other integrated farms may include Crystal Diamond (with a market share of 10%), Tet Chaung (with market share 6-8%) and MRT (with less than 5% market share) (IFC 2016). Moreover, the broiler industry is mainly led by international companies with contract agreements with smallholder farmers. A recent study shows that international firms and contract farmers produce about 60% of the country's broilers, while the remaining 40% is produced by independent farmers (SAPA 2021).

4

Smallholder chicken production and productivity

4.1 Type of chicken breeds

The type of chicken breeds used under the smallholder production system may include indigenous, exotic and hybrid breeds. The major indigenous breeds include Taik Kyet, Tainnyin Kyet, Kyet Lada, Sittagaung, Inbyinwa Kyet and Hle Pyiang (MOECF 2015; Jupamatta et al. 2017; Henning and Pym 2019). The indigenous chicken can be categorized into two groups, namely Myanmar native chicken (MNC) and Myanmar Fighting Cock (MFC) (Jupamatta et al. 2017). The exotic breeds may include RIR, New Hampshire, Austrolop, Barred Plymouth Rock, White Plymouth, Light Sussex, White Leghorn and Cornish (NCC 2003).

4.2 Chicken management

Chicken management practices under smallholder production depend on the type of production system adopted by the producers. As indicated above, chicken management is considered inadequate in the traditional/backyard production system (Henning et al. 2006) and producers mostly provide limited supplementary feeds from local sources (Win 2012). Producers in the smallholder production system hardly practice housing and chickens may stay in the owner's house, any house in the compound, or trees (Win 2013). Disease prevention and treatment measure are minimal due to a lack of producers' knowledge and skills in poultry health and inadequate access to veterinary services (Henning et al. 2006). Some smallholder producers adopt better management practices such as improved feed, housing, health and biosecurity measures under semi-intensive production.

4.3 Chicken productivity

The productivity of indigenous chicken under smallholder traditional/backyard production is generally considered low (Henning et al. 2009b; Win et al. 2019). The low productivity could be associated with genetic and management-related factors. Producers usually keep smaller flocks (about 12) sizes (LBVD 2019). A hen lays 12 eggs per clutch for three clutches in a year (Burgos et al. 2009). The eggs are usually used for chick production with an average hatchability of 75-85% (Henning and Pym 2019) and chicks' survival rate of 40-66% (Burgos et al. 2009; Win 2012). According to Jupamatta et al. (2017), the bodyweight of adult Myanmar male and female native chicken is 1.65±0.61 kg and 1.49±0.63 kg, respectively. Similarly, the bodyweight of Myanmar fighting cock's and adult females is 1.94±0.36 and 1.23±0.47 kg, respectively. The productivity indicators reported above show the chicken's low productivity mainly kept by smallholder producers.

4.4 Major production constraints

The low productivity of smallholder poultry production could be associated with different bottlenecks. These may include the limited genetic potential of chicken, inadequate management practices, high disease prevalence, predatory attack and unfavourable environmental conditions (Henning et al. 2009a; IFC 2016; MOALI and JICA 2018). Increased mortality of birds (greater than 60%), especially chicks, could be associated with inadequate feeding and housing practices. This seems to be the primary constraint, especially under the traditional/backyard production system (Win 2012; Pym 2017). Moreover, limited skills and knowledge of producers and limited access to finance are the other main constraints reported under the smallholder production system (Burgos et al. 2009; Win 2012; Raitzer et al. 2015; Pym 2017; Henning and Pym 2019; Sherman et al. 2019; Belton et al. 2020). Although there have been improvements in the previous decades, the supply of quality and affordable poultry feeds remains the major production constraint in the country (Belton et al. 2020). Therefore, interventions that enhance the genetic potential of birds, supply of locally available feeds, the health of birds and better management options will have a significant role in improving smallholder chicken production and productivity (Henning et al. 2009b; Morton et al. 2013; Sherman 2018).

5

Poultry products marketing

5.1 Overview of the poultry market

The production systems mentioned above have diverse marketing channels and outlets. While smallholder producers use different marketing outlets, commercial producers usually have specific marketing outlets. Most smallholder chicken producers participate in the marketing of live birds and eggs (Henning et al. 2007; Win et al. 2019). They sell poultry products directly to consumers or collectors in the local markets and villages. Unlike smallholder producers, commercial producers sell meat and eggs mainly to wholesale traders in the central market and very few of them sell in the local markets (Belton et al. 2020). Commercial producers have well-established supply chains and a very small proportion of them sell to village-level brokers and directly to consumers. Commercial producers' have a better relationship with their buyers and most of their buyers collect poultry products at farm gate. According to Belton et al. (2020), there is low intermediation in the commercial producers' supply chain. Most farmers sell directly in the wholesale markets than local markets or through collectors. The commercial poultry production system is one of the agricultural sectors with vertically integrated farms, including processing facilities (IFC 2020).

Empirical evidence shows that there has been a significant increase in the demand for poultry products due to an increase in population, urbanization and increase in income (Henning and Pym 2019). Moreover, due to limited preference for beef consumption, there is an increasing demand for poultry products consumption. This would create a better opportunity for smallholder and commercial poultry producers. The price of local chickens is significantly higher than improved chicken due to their preferred tests (Henning and Pym 2019). This is an excellent incentive to sustain local chicken species under a smallholder production system. Sometimes smallholder producers sell local chicken and buy cheaper improved chicken for consumption (Sherman 2018).

Most birds are sold live and slaughtered manually around the live bird markets (Burgos et al. 2009; IFC 2016). The largest live bird mixed market is found in the country's capital city. Thousands of live birds from different regions such as Yangon, Bago and Ayeyarwaddy are daily supplied to this market (Burgos et al. 2009). This market has different veterinarians who monitor the health status of incoming birds and make approval for sale. The overall poultry inputs and output market structure in Myanmar seem concentrated (IFC 2016). Very few companies such as CP Myanmar and Japfa Maykha share the largest proportion of the market share for feed production, breeder farms, hatcheries, day-old-chick (DOCs) production, commercial broiler farming and a slaughterhouse (IFC 2016). This shows the inefficiency of the marketing system that has an astringent impact on the production and consumption of poultry products.

5.2 Smallholder poultry products marketing chains

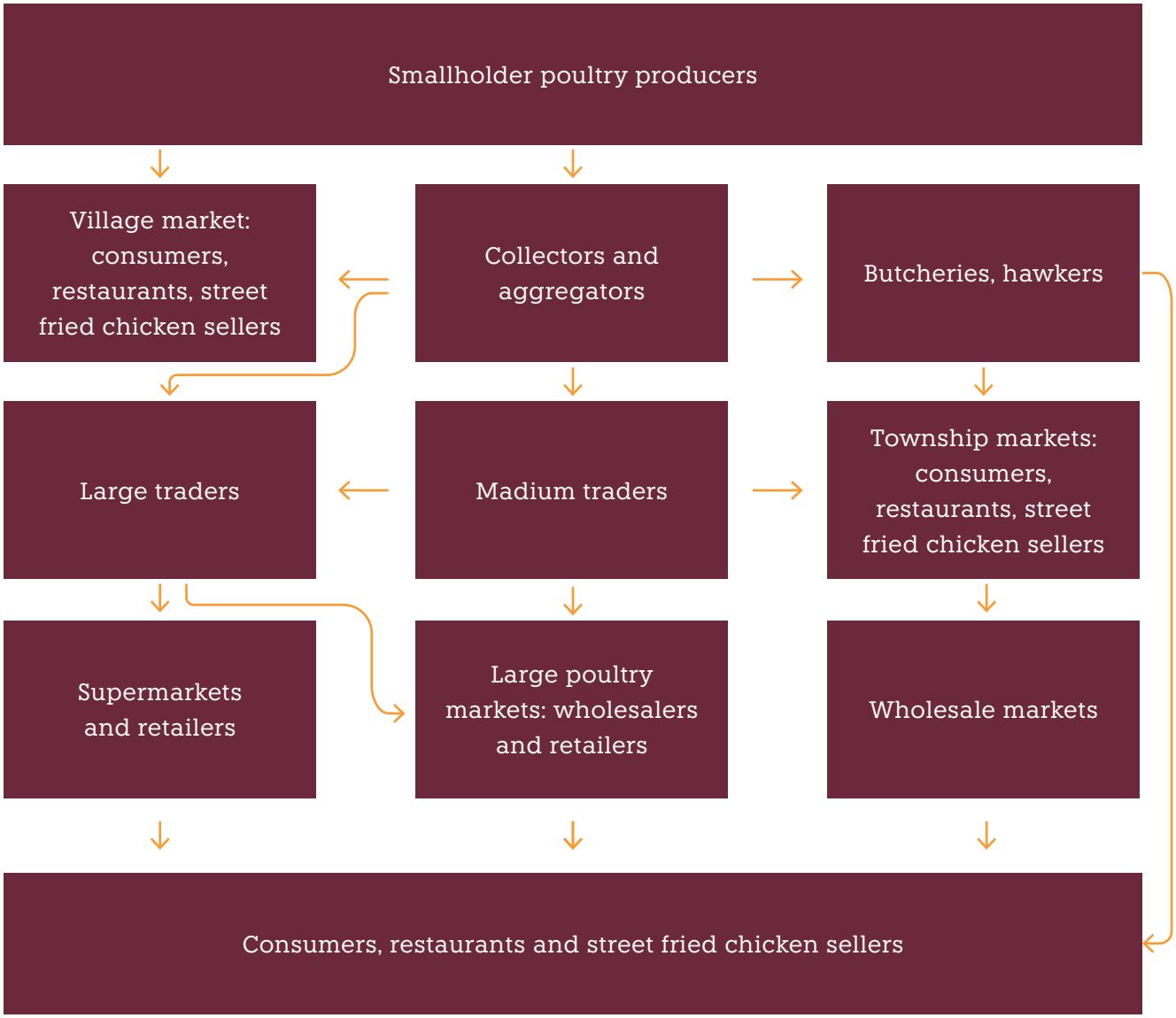
Smallholder poultry products flow through different marketing channels, including local markets, the township market and the wholesale market (Win 2012). Figure 9 presents an overview of possible marketing channels for smallholder poultry products in the country. In the first channel, producers can sell products directly to buyers around the villages in the local market, such as individual consumers, fellow farmers, restaurants and fried chicken sellers. Direct selling to local consumers may be undertaken at farmgate or village markets. The second marketing channel, selling through collectors/aggregators, is the main marketing channel for smallholder producers. Collectors can assemble birds from an average of 10 villages daily (Henning et al. 2006). Usually, they move from village to village and collect chicken from smallholder farmers (Henning et al. 2006). Sometimes collectors work with brokers who search for marketable chicken and inform them for collection. They collect the products using bicycles or motorcycles and sell products to local buyers such as large and small restaurants, street fried chicken sellers, butchers and hawkers or take the poultry products to the township and wholesale markets. The township market refers to larger markets in towns and urban areas and the wholesale markets refer to central markets where there are better quality control, price awareness, disease monitoring and control and high competition (Burgos et al. 2009). In the township and wholesale markets, the collectors usually sell products to medium and large traders, processors like butchers and hawkers.

Large traders usually sell to retailers (supermarkets and shops) and other wholesalers at larger poultry markets that resell the products to consumers and processors. Sometimes medium traders sell to other traders in the large poultry market that sells to consumers, restaurants and fried chicken sellers. Retailers and wholesalers in the township and wholesale market sell to different buyers, including individual consumers, restaurants and hotels, fried chicken sellers and other buyers. In all marketing segments, collectors and traders are the main actors moving the products from smallholder producers to consumers. Chickens are usually sold as meat after processing in the wholesale markets (Win 2012). In some markets, government and private veterinarians monitor and certify the health status of all incoming birds and approve sales at vending stalls (Burgos et al. 2009).

5.3 Marketing constraints

For smallholder producers, the main marketing constraints include inadequate supply to fulfil potential demand (quantity and quality for indigenous breeds), market price fluctuation, inadequate marketing infrastructures, disease, inadequate food safety and hygiene and limited access to better markets (Burgos et al. 2009; MOALI and JICA 2018; Win 2018). Due to the low productivity of indigenous chicken, the existing supply does not meet the demand. There is high seasonal price fluctuation in the live bird market, where the low-price season falls from March to July and the high-price season from October to December (Burgos et al. 2009). The price fluctuation could be associated with seasonal demand and supply changes, disease incidence, natural disasters and other environmental hazards. Limited access to the market could be related to farmers long-distance travel to sell products, high transportation costs and inadequate opportunities for farmers for processing facilities (Win 2012). Poor processing methods such as inadequate clearing of eggs, poor slaughtering facility for birds, limited quality control, poor hygienic and sanitation in marketing places could also be considered the most important constraints. High mortality and weight loss during transportation could also be the other marketing challenges. In commercial broiler production, inadequate cold chain and modern slaughter system are also the major challenges.

Figure 9: Smallholder poultry products marketing channels.



Source: Adopted from Henning and Pym (2019) and Win (2012)

6

The nutritional contribution of smallholder poultry production

6.1 Households nutrition and possible interventions in Southeast Asian countries

Malnutrition has become a global development and health challenge in developing and developed countries. Malnutrition refers to both undernutrition (underweight wasting, stunting and micro-nutrient deficiency) and overnutrition (overweight/obesity and micro-nutrient excess) (UNICEF 2016). Most Asian countries are affected by the double burden of undernutrition and overnutrition, such as stunting, underweight, wasting, micronutrient deficiencies, overweight/obesity and micronutrient excess (UNICEF 2016). In 2019, the average undernutrition prevalence in Southeast Asia was 9.8%, which is slightly higher than the regional (8.3%) and global (8.9%) averages (FAO 2021). Similarly, the proportion of under-five stunted children was 24.7% and this prevalence is higher than the regional (21.8%) and global (21.3%) averages. Stunting mainly results from a more extended period of nutritional deprivation and yields growth and development retardation, including delayed mental development and educational performance that affect productivity (WHO 2010; Dewey and Begum 2011). Maternal stunting can restrict uterine blood flow and growth of the uterus, placenta and fetus, intrauterine growth restriction (IUGR) (Black et al. 2013). These may result in many adverse fetal and neonatal outcomes, chronic fetal distress or fetal death and other serious medical complications after birth (Black et al. 2013). Child undernutrition can also be a primary cause of child death, illness and disability (UNICEF 2016).

Major underlying causes for malnutrition include multiple factors such as insufficient access to healthy food; inadequate care; feeding practice and behaviour; sedentary lifestyle and behaviour; poor water, sanitation, food safety and inadequate health services (Haddad et al. 2015; UNICEF 2016). Hence success in nutritional improvement may include nutrition-specific interventions and nutrition-sensitive interventions (Khalid et al. 2019). While nutrition-specific intervention addresses the immediate determinants of fetal and child nutrition and development, nutrition-sensitive interventions influence the underlying nutrition determinants (Ruel and Alderman 2013; IFPRI 2016; Gillespie et al. 2019). According to IFPRI (2016), nutrition-specific interventions include Vitamin A and zinc supplementation, exclusive breastfeeding, dietary diversity promotion and food fortification. Similarly, nutrition-sensitive intervention may enhance agricultural production and food

security; water sanitation and hygiene; child protection and development; health and family planning services; social safety nets; and maternal health and women's empowerment (Ruel and Alderman 2013). In developing countries like Southeast Asia, enhancing household nutrition requires integrated interventions including:

» home/kitchen gardens production;
» collective vegetable gardening;
» improved poultry production;
» nutrient-dense/biofortified crops production and food product fortification;
» integrating nutrition advice into agricultural extension platforms;
» promotion of nutritious traditional crops and foods;
» biofortified transgenic crops (Glover and Poole 2019).

There have been some research and development initiatives in southeast Asia that aimed to enhance the nutrition outcomes of agricultural interventions (Pandey et al. 2016). Leveraging Agriculture for Nutrition in South Asia (LANSA) could be an excellent example of such initiatives (Bird et al. 2019). Such type of interventions helps to enhance households understanding of how agriculture and related interventions can be designed and implemented to improve nutritional outcomes of children and women in developing countries (Gillespie et al. 2019). However, interventions that aim to enhance the nutritional status of households should make the following primary consideration: focus on the first 1,000 days of children; build on maternal and child cash transfer; provision of nutritious foods in safety-nets; leverage education platform to reach children and adolescents; diversify agriculture production, improve availability and nutrient content of foods, target interventions for specific livelihoods; and improving farm-level productivity and reducing the cost of marketing (Mahrt et al. 2019; WFP 2019). A sustained outcome in nutrition improvement may require enhancing availability and access to nutritious food by engaging both the public and private sectors (Bloem et al. 2013).

6.2 Diet diversity and undernutrition in Myanmar's households

Households' healthy diet practice can be measured by Household Dietary Diversity Scores (HDDS), a universally recognized measure of household food consumption (Ruel 2003). This measure shows the number of food groups consumed by households with a given period. According to WFP (2019), dietary diversity in Myanmar seems suboptimal and the majority of the households could not afford diets that meet nutritional needs. Regional and household wealth status disaggregated HDDS indicators show significant HDDS variability between different regions and household wealth status. From the seven food groups, in 2017/18, the HDDS diversity between different regions ranges from 4.2 to 7.0 (MOHS 2019). The highest HDDS was recorded in Bago and the lowest in Chin regions. The wealth index based disaggregated HDDS shows that households in the lowest quantile had 5.1 HDDS while households in the highest quantile had 6.2 HDDs. Households in the rural areas also had lower HDDS than households in the urban areas. According to Win and Cashin (2016), dietary diversity among children aged 6 to 23 months was poor in their program areas. Only 21% of children in the study area had adequate dietary diversity. Young women (25-19 years) in the Yangon region of Myanmar had poor quality of nutrition and only 47% of the sample had minimum dietary diversity (Goudet et al. 2020).

There is a strong association between HDDs and undernutrition in Myanmar (Win and Cashin 2016; Hein et al. 2019; MOHS 2019). Although there was a significant decline in the proportion of stunted children (under five years) from 42.7% in 2003 to 29.4% in 2016, undernutrition remains the main challenge in the country (Khaing et al. 2019; FAO 2021). For instance, in 2017/18, the proportion of 6-59 months stunted children was 26.7%. The regional level disaggregated data also shows that Chin state had the highest (40.3%) stunting rate.

As indicated by the HDDs, a higher proportion of stunted children in this state could be associated with an inadequate intake of essential micronutrients. The prevalence of anaemia among children and women of reproductive age was high. For instance, 36.5% of children (6-59 months) and 30.3% of women of reproductive age (15-49 years) had been affected by anaemia in 2017/18. However, the proportion of anaemic reproductive age women was significantly higher than the global average in the previous decades. From 2000 to 2016, the average prevalence of anaemia among women of reproductive age was 42.34%, while the global average in the same period was 30.8% (FAO 2021). Higher undernutrition was observed in rural and poor households than in urban and wealthy households.

The main underlying reasons for lower dietary diversity in the country may include low agricultural productivity, location, household wealth status, land size, increasing price of foods and limited nutritional knowledge and skills (Moe 2013; Win and Cashin 2016). Low productivity associated with a shortage of capital and limited access to land was indicated as the major constraint to access basic food items in the country (Moe 2013). Households' location has an important role in diversifying food consumption due to socio-economic, cultural and religious reasons. For instance, children in Chin state have significantly lower dietary diversity than children in other states. The observed inadequate HDDS and undernutrition could also be associated with over-consumption of staples and under-consumption of all non-staple food groups (Mahrt et al. 2019). Research shows that most households consume staple grains, mainly rice and other staples. Based on 24 hours recall data, Hein et al. (2016) study examined that only 30-40% of the households consumed protein-rich foods such as meat, eggs, or dairy products. Egg is the second least frequently consumed food item in the study areas, while fish and seafood are the most frequently consumed food items. Although household food preference, religion and culture and nutrition knowledge are essential factors, limited access to nutrient-dense foods could be the major limiting factors for the observed undernutrition (Bloem et al. 2013; Downs et al. 2018; Mahrt et al. 2019; Rammohan et al. 2019). Hence, enhancing household nutritional status may need improving crop and livestock production and productivity (i.e. eggs, meat and vegetables), diversifying household incomes and building households behaviour in consumption of recommended food groups (Win and Cashin 2016; Pritchard et al. 2019; Rammohan et al. 2019). In this regard, poultry production would play an important role. Some research findings have underlined the vital role of non-farm incomes in household food security and dietary diversity in rural areas (Pritchard et al. 2019).

6.3 Contribution of poultry production to diet diversity

In developing countries, poultry production has a crucial contribution to household diet diversity and nutrition through its impact in different pathways such as increased household income, own food production and consumption and women empowerment (Onyeneke et al. 2020). The positive association between poultry production and dietary diversity is documented in various studies (Taruvinga et al. 2013; Wong et al. 2017; Lutte 2020; Onyeneke et al. 2020; Passarelli et al. 2020). Poultry products such as eggs and meat have essential nutrients that enhance household nutrition. According to Iannotti et al. (2014), eggs supply essential fatty acids, proteins, choline, vitamins A and B12, selenium and other critical nutrients. Consumption of poultry meat provides moderate energy; highly digestible proteins; unsaturated lipids; B-group vitamins like thiamin, vitamin B6, pantothenic acid; and minerals including iron, zinc and copper (Marangoni et al. 2015). Consumption of chicken meat has a vital role in improving specific age groups' nutritional status, such as pregnant women, children and the elderly (Marangoni et al. 2015). Enhancing the capacity and ability of smallholder producers to adopt improved poultry production results in increased egg and live bird production, leading to consumption of nutritious food and higher gain in households income (Wong et al. 2017; Alders et al. 2018). Given the important role of poultry production in poverty reduction and food security, improving the sector's production and productivity would help achieve multiple development goals (Iannotti et al. 2014)

7

The economic contribution of smallholder poultry production

As indicated above, smallholder poultry production is an integral part of agricultural activities that supply meat and eggs for home consumption and income generation (Henning et al. 2006). Most smallholder poultry producers participate in marketing poultry products to generate income and support other likelihood activities. A study conducted by Win et al. (2019) showed that about 99.8% of chicken producers in the central dry zone of Myanmar keep chicken to generate income. The majority of the village chicken producers primarily keep chicken for cash sale (77.2%) than for consumption (22.6%) and cockfighting (0.2%). Although there is no comprehensive evidence on the income contribution of poultry production at the household level, its economic contribution at a different level of the value chain is documented by empirical researches (Burgos et al. 2009; Henning and Pym 2019). Smallholder poultry production helps producers, collectors and traders to generate modest income. However, the income contribution of producers around the urban areas is significantly higher than producers in remote areas due to access to better markets (Burgos et al. 2009).

The poultry sector in Myanmar is identified as one of the potential sectors for investment as it could bring developmental and social impacts (IFC 2016). Growth in small/medium scale commercial production would create significant employment opportunities for youth and landless households in the country (Belton et al. 2020). Unlike traditional/backyard production, smallholder producers that adopt semi-intensive production can generate better income. According to IFC (2016), a farmer can earn USD1,500-2,000 over one and half months from broiler or layer farm production, which could be obtained from an Acer of land in a year. According to Henning and Pym (2019), indigenous breeds-based semi-intensive production can create business opportunities for women to generate income that supports households' livelihood. Moreover, poultry production is among the best poverty reduction strategies as it attracts landless and near-landless households (Haggblade et al. 2014). According to MOALI (2016), the lower production cycle and low input requirement of poultry production make it suitable for entry points for poverty reduction among resource-poor households in the country.

8

Overview of agricultural policy and livestock research

Agricultural productivity in Myanmar is generally considered low compared to other countries in the region (CSO et al. 2020). Among others, this low productivity could be associated with unpredictable policies, underinvestment in agricultural researches, poor linkages between extension workers and farmers, limited access to technology, limited access to finance and limited market access (Haggblade et al. 2014; CSO et al. 2020). The agricultural policy in Myanmar is formulated in the context of national policies, national plans and national laws and regulations (MOALI 2018). Myanmar has different policies and strategies, including the 2016 National Economic Policy, the 2012 Framework for Economic and Social Reforms (FESR), the 2011 National Comprehensive Development Plan (NCDP), which includes five-year series of plans from 2011-31. The NCDP has long-term and short-term visions associated with agricultural and rural developments (MOALI 2018). The short-term visions include improving agricultural productivity, increasing small/medium agricultural enterprise, attracting Foreign Direct Investment (FDI) in the agricultural sector, enhancing domestic and export markets and market infrastructure, conducting applied and pure research and enhancing the efficiency of value chains.

In 2016/17, MOALI developed Agriculture Development Strategy (ADS) to consolidate and integrate various plans, strategies and roadmaps; to develop a systematic approach and operationalize agricultural policy implementation and link it to Investment Plans (IP); to coordinate activities, projects, programs and policies; and to build a dialogue with domestic and foreign investors (MOALI 2018). ADS aims to increase food and nutrition security, reduce poverty, enhance competitiveness and improve income, equity and farmers' rights.

Due to the vital role of agriculture in the overall economy and the existing production and productivity gap, agricultural research, extension and development have been an integral component of the ADS and other national-level policies and strategies (Tun et al. 2015; MOALI 2018). In Myanmar, agricultural researches have been overseen by the Ministry of Agriculture and Irrigation (MOAI), the Ministry of Forestry (MOF) and the Ministry of Livestock and Fisheries (MOLF)(Cho 2013). Under MOAI, the Department of Agricultural Research (DAR) leads crop, soil, water utilization; agronomy, agricultural economics; and biotechnology and plant genetic research. Under MOLF, LBVD leads livestock research and development activities, including livestock production, livestock health, artificial insemination, reproductive disorders and extension services. In addition to government-funded research projects, there have been various donor-funded projects that support the research and development activities of the country. This may include Livelihood and Food Security Fund (LIFT), Japan International Cooperation Agency (JICA) and Korea International Cooperation Agency (KOICA) funded projects (Stads et al. 2019).

The agricultural research in Myanmar is considered highly underfunded, fragmented, and has an inadequate role in solving potential problems (Boughton and Win 2019). Despite good progress in strengthening the research capacity of the country, in the previous few years, the share of agricultural research funding to Agricultural GDP (AgGDP) remains very low (i.e. 0.06% only in 2017) (Stads et al. 2019). Compared to other countries in the region, the overall average agricultural research spending is significantly low. For instance, during 2017, the agricultural spending in Myanmar was 5.5%, 7.4% and 26.2% of the spending in Thailand, Indonesia and Vietnam (ASTI 2021). Moreover, existing research and development efforts mainly focus on crop researchers and the attention given to livestock research is minimal (Boughton and Win 2019). In 2017, the share of livestock FTE (Full-time equivalent) researchers was 3.6%, while total crop researchers' share was about 80.9% FTE (Stads et al. 2019). This shows the inadequate attention given to the livestock research activities in the country, which could result in the lower productivity of the sectors in the previous decades.

Livestock research mainly includes veterinary medicine, animal husbandry, animal nutrition and animal breeding/genetics. Most livestock research has focused on veterinary medicine, animal nutrition and animal husbandry than animal breeding/genetics (Stads et al. 2019). Research on livestock breeding/genetics for smallholder producers in the country seems inadequate and this has resulted in a lack of genetic progress and inbreeding, especially in small ruminants (MOALI 2016). Hence, the country has planned breed improvement programs on draft beef, dairy cattle; sheep and goats; and pigs. Researches in the livestock sector adopt adaptively and apply researches as a first and second strategy (MOALI 2018). This includes field-based research with the active participation of farmers and adaptation research for improved technologies. Moreover, recent evidence shows that livestock breed improvement has been among the short-term policy measure included in the Food Value Chain road map of the government of Myanmar that aims to increase livestock production and productivity (MOALI and MAFF 2017).

As indicated above, the production and productivity of the poultry sector have remained low and uncompetitive compared to other countries in the region. For instance, it costs around USD 1.6 per kg to produce meat compared to USD 1 per kg in Brazil (IFC 2016). This could be associated with existing constraints and the inadequate research and development attention given to the sector. Although there is no national-level strategy for the poultry sector, in Myanmar, poultry development is considered one of the targets in the Livestock and Fishery sector (IFC 2016). Moreover, poultry production is one of the major priority sectors in the livestock development strategy due to its multidimensional contribution to smallholder producers and the country's overall economy (MOALI 2016). Therefore, improved husbandry practices for indigenous chicken, sustainable production, marketing strategies, building capacity of farmers, breeding facilities, health and biosecurity and improved networking are identified as potential research areas in the sector (Henning and Pym 2019).

There have been some research and development efforts in the smallholder poultry sector of the country. Recent research by Henning and Pym (2019) is a good example. This research shows the role of diversifying indigenous poultry production through better management options such as intensive/semi-intensive production systems in smallholder livelihoods. Given consumers' higher preference for indigenous chicken products, efforts that improve the production and productivity of the traditional/backyard production system will have a significant economic and social return (MOALI and JICA 2018). Similarly, a study conducted by Henning et al. (2013) shows the contribution of vaccination and improved chick management to enhance the profitability of village chicken production. However, most of the previous research efforts focused on improved feed, health and management options (IFC 2016; Henning and Pym 2019). For successful and sustainable transformation of the sector, additional research on breed improvement and genetics, input and output marketing systems, technology dissemination and building capacity of farmers and food safety and hygiene are required.

9

Conclusion and research opportunities

The main purpose of this review is to understand existing poultry production, marketing and consumption practices and identify research and development gaps and opportunities in Myanmar. The review shows that poultry production plays an irreplaceable role in rural households' livelihood and the country's overall economy. It supplies the largest proportion of meat and egg consumed in the country and has a vital role in enhancing households' nutrition, food security and income generation. Despite a growing trend in semi-intensive and intensive production, the traditional/backyard poultry production system remains the most common production system in the country.

Preference for indigenous poultry products seems to be increasing due to changes in consumers' perception of health and environmental issues. However, production and productivity at the smallholder level remain low due to the limited genetic potential of indigenous breeds, inadequate husbandry practices, higher disease prevalence, bird mortality, inadequate inputs access and delivery system and other marketing-related constraints. Approaches to address various constraints demand interdisciplinary and integrated research and development efforts. These may include developing innovations that enhance the production and productivity of existing breeds; building the capacity of input suppliers, producers and marketing actors; establishing a partnership for effective input delivery and output marketing; and enhancing the overall performance of the value chain. Research and development efforts to improve the production and productivity of existing breeds may adopt the following approaches: Improving the genetic potential of existing breeds, introducing locally adapted and farmer-preferred improved breeds and developing innovative and context-specific management practices that enhance the competitiveness and efficiency of different production practices.

References

Alders, R.G., Dumas, S.E., Rukambile, E., Magoke, G., Maulaga, W., et al. 2018. *Family poultry: Multiple roles, systems, challenges, and options for sustainable contributions to household nutrition security through a planetary health lens.* Maternal & Child Nutrition 14 (S3): e12668.

ASTI (Agricultural Science and Technology Indicators). 2021. *Country benchmarking–South East Asia: Spending / Million 2011 PPP dollars.* Available from https://www.asti.cgiar.org/benchmarking/southeast-asia?country=MMR (Accessed 6 April 2021).

Aung, A. 2019. *Leucaena feeding systems in Myanmar: Sistemas de alimentación de ganado con leucaena en Myanmar.* Tropical Grasslands-Forrajes Tropicales 7(4): 423–427.

Belton, B., Cho, A., Payongayong, E., Mahrt, K. and Abaidoo, E. 2020. *Commercial poultry and pig farming in Yangon's Peri-Urban Zone.* Research paper Michigan State University.

Bird, F.A., Pradhan, A., Bhavani, R.V. and Dangoura, A.D. 2019. *Interventions in agriculture for nutrition outcomes: A systematic review focused on South Asia.* Food Policy 82:39-49.

Black, R.E., Victora, C.G., Walker, S.P., Bhutta, Z.A., Christian, P., et al. 2013. *Maternal and child undernutrition and overweight in low-income and middle-income countries.* Maternal & Child Nutrition 382 (9890): 427-451. DOI:10.1016/S0140-6736(13)60937-X.

Bloem, M.W., Pee, S.d., Hop, L.T., Khan, N.C., Laillou, A., et al. 2013. *Key strategies to further reduce stunting in Southeast Asia: Lessons from the ASEAN countries workshop.* Food and Nutrition Bulletin 34 (S8-S16).

Boughton, D. and Win, S.S. 2019. *Agricultural research capacity and extension linkages in myanmar: assessment and recommendations.* Research paper. Michigan State University.

Burgos, S., Otte, J. and Roland-Holst, D. 2009. *Poultry, HPAI and livelihoods in Myanmar – A review.* Mekong team working paper no. 8. Rome: FAO.

Cho, K.M. 2013. *Current situation and future opportunities in agricultural education, research and extension in Myanmar.* Background paper. Michigan State University & Myanmar Development Resource Institute.

CSO, UNDP and WB (Central Statistical Agency, United Nations Development Programme and the World Bank). 2020. *Myanmar living conditions survey 2017: Socio-economic report*. Nay Pyi Taw and Yangon, Myanmar: Ministry of Planning, Finance and Industry, UNDP and WB.

Dewey, K.G. and Begum, K. 2011. *Long-term consequences of stunting in early life.* Maternal and Child Nutrition 7:5–18.

Downs, S.M., Glass, S., Linn, K.K. and Fanzo, J. 2018. *The interface between consumers and their food environment in Myanmar: an exploratory mixed-methods study.* Public Health Nutrition 22 (6):1075–1088.

Fang, P., Belton, B., Zhang, X. and Win, H.E. 2021. *Impacts of COVID-19 on Myanmar's chicken and egg sector, with implications for the sustainable development goals.* Agricultural Systems 190:103094.

FAO (Food and Agriculture Organization of the United Nations). 2021. *FAOSTAT Statistical Database.* 2021 ed. Rome: FAO.

Gillespie, S., Poole, N., Bold, M.v.d., Bhavani, R.V., Dangour, A.D. et al. 2019. *Leveraging agriculture for nutrition in South Asia: What do we know, and what have we learned?* Food Policy 82:3-12.

Glover, D. and Poole, N. 2019. *Principles of innovation to build nutrition-sensitive food systems in South Asia.* Food Policy 82: 63–73.

Goudet, S., Hlaing, L.M. and Griffiths, P.L. 2020. *Exploring food security and nutrition among young women in the formally regulated garment sector of Myanmar.* Ann. N.Y. Acca. Science 1468: 35–54. DOI:10.17028/rd.lboro.12608726.v1

Haddad, L., Cameron, L. and Barnett, I. 2015. *The double burden of malnutrition in SE Asia and the Pacific: priorities, policies and politics.* Health Policy and Planning, 30:1193–1206.

Haggblade, S., Boughton, D., Cho, K.M., Denning, G., Kloeppinger-Todd, R., et al. 2014. *Strategic choices shaping agricultural performance and food security in Myanmar.* Journal of International Affairs 67 (2): 55-71.

Hein, A.K., Hong, S.A., Puckpinyo, A. and Tejativaddhana, P. 2019. *Dietary diversity, social support and stunting among children aged 6–59 months in an internally displaced persons camp in Kayin State, Myanmar.* Clinical Nutritiion Research 8(4): 307-317.

Henning, J., Khin, A., Hla, T. and Meers, J. 2006. *Husbandry and trade of indigenous chickens in Myanmar—Results of a participatory rural appraisal in the Yangon and the Mandalay divisions.* Trop Anim Health Prod, 38:611–618. DOI:10.1007/s11250-006-4425-1.

Henning, J., Meers, J., Morton, J., Pym, B. and Hla, T. (2009a). *Village chickens in Myanmar: characteristics, constraints and methods for improving health and production.* In: Alders, R.G., Spradbrow, P.B. & Young, M.P., eds. Village chickens, poverty alleviation and the sustainable control of Newcastle disease. Dar es Salaam, Tanzania. Australian Centre for International Agricultural Research (ACIAR).

Henning, J., Morton, J., Pym, R., Hla, T. and Meers, J. 2009b. *Evaluation of strategies to improve village chicken production-controlled field trials to assess effects of Newcastle disease vaccination and altered chick rearing in Myanmar.* Preventive Veterinary Medicine, 90 (1-2), 17-30.

Henning, J., Morton, J., Pym, R., Hla, T., Sunn, K., et al. 2013. *Economic analysis of interventions to improve village chicken production in Myanmar.* Preventive Veterinary Medicine 110 (3–4):525-540.

Henning, J., Pym, R., Hla, T. and Kyaw, N. 2007. *Village chicken production in Myanmar – purpose, magnitude and major constraints.* World's Poultry Science Journal 63 (2): 308-322.

Henning, J. and Pym, R.A. 2019. *Diversifying rural poultry production in Myanmar –opportunities for small-scale farmers.* Canberra, Australia: ACIAR.

Iannotti, L.L., Lutter, C.K., Bunn, D.A. and Stewart, C.P. 2014. *Eggs: The uncracked potential for improving maternal and young child nutrition among the world's poor.* Nutrition reviews 72 (6): 355-368. DOI:10.1111/nure.12107.

ICEM (International Centre for Environmental Management). 2014. *USAID Mekong ARCC climate change impact and adaptation on livestock.* Livestock report–Prepared for the United States Agency for International Development by ICEM. Bangkok: USAID Mekong ARCC Project.

IFC (International Finance Corporation). 2016. *Private sector window: Agribusiness country diagnostic – Myanmar.* In: CEPA (ed.) Global Agriculture and Food Security Program (GAFSP).

IFC. 2020. *Creating markets in Myanmar: Building Markets for a Sustainable Economic Recovery. A Country Private Sector Diagnostic.* Washington, D.C.: World Bank.

IFPRI (International Food Policy Research Institute). 2016. *Global nutrition report 2016: From promise to impact: Ending malnutrition by 2030.* Washington, DC: IFPRI.

JBI. 2020. *JBI Manual for Evidence Synthesis*. JBI.
(Available from: https://synthesismanual.jbi.global. https://doi.org/10.46658/JBIMES-20-01) (Accessed 10 June 2021).

Jupamatta, A., Saekwao, P., Maung, K.G., Sein, M.M., Kyaw, M.M., et al. 2017. *Biodiversity of chicken in Yangon Division, Union of Myanmar between November, 2015 and July, 2016*. Journal of Thai Interdisciplinary Research 13 (4): 55-62.

Khaing, H.T., Nomura, S., Yoneoka, D., Ueda, P. and Shibuya, K. 2019. *Risk factors and regional variations of malnutrition among children under 5 in Myanmar: cross-sectional analyses at national and subnational levels.* BMJ Open 9 (e030894). DOI:10.1136/bmjopen-2019-030894.

Khalid, H., Gill, S. and Fox, A.M. 2019. *Global aid for nutrition-specific and nutritionsensitive interventions and proportion of stunted children across low- and middle-income countries: does aid matter?* Health Policy and Planning 34: ii18–ii27.

Larive-International. 2015. *Report Myanmar poultry expert visit 15-19 March 2015.* The Netherlands: Netherlands Enterprise Agency (RVO).

LBVD (Livestock Breeding and Veterinary Department). 2019. *National Livestock Baseline Survey (NLBS) 2018.* Nay Pyi Taw: LBVD.

LIFT (Livelihood and Food Security Fund). 2019. *Farming systems in myanmar: methodological background and synthesis of field-based studies across five states and regions of Myanmar.* LIFT.

Lutte, C.K. 2020. *Building the evidence base around poultry production for nutrition.* The Journal of Nutrition 150(10): 2617–2618.

Mahrt, K., Mather, D., Herforth, A. and Headey, D.D. 2019. *Household dietary patterns and the cost of a nutritious diet in Myanmar.* USA, Department of Agricultural, Food, and Resource Economics, Michigan State University.

Marangoni, F., Corsello, G., Cricelli, C., Ferrara, N., Ghiselli, A., et al. 2015. *Role of poultry meat in a balanced diet aimed at maintaining health and wellbeing: an Italian consensus document.* Food & Nutrition Research 59: 27606.

MOALI (Ministry of Agriculture, Livestock and Irrigation). 2016. *Formulation and operationalization of National Action Plan for Poverty Alleviation and Rural Development through Agriculture (NAPA). Livestock production, extension and applied research.* Yangon: Ministry of Agriculture, Livestock and Irrigation.

MOALI. 2018. *Myanmar agriculture development strategy and investment plan (2018-19 ~ 2022-23).* In: MOALI (ed.). Myanmar.

MOALI and JICA (Japan International Cooperation Agency). 2018. *Data collection survey for food value chain development assistance in the Republic of the Union of Myanmar: Final report.* Japan International Cooperation Agency (JICA).

MOALI and MAFF. 2017. *Food value chain road map (2016-2020) in Myanmar.* In: Ministry of Agriculture, L.a.I., Myanmar and Ministry of Agriculture, Forestry and Fisheries, Japan (ed.).

Moe, Z.A. 2013. *Overview of food accessibility situation in Myanmar.* In: Castano, J.G. (ed.) Thematic Paper on Myanmar Census of Agriculture 2010.

MOECF (Ministry of Environmental Conservation and Forestry). 2015. *National Biodiversity Strategy and Action Plan* (2015-2020). Available from: https://www.fao.org/faolex/results/details/en/c/lex-faoc161482/

MOHS (Ministry of Health and Sports). 2019. *Myanmar Micronutrient and Food Consumption Survey (MMFCS 2017-2018).* Interim report. Nai Pyi Taw, Myanmar: Ministry of Health and Sports.

MOPF (Ministry of Planning and Finance). 2019a. *Myanmar Agricultural Statistics: 2008-2018.* Nay Pyi Taw, Myanmar: Central Statistical Organization (CSO).

MOPF 2019b. *Myanmar Statistical Yearbook-2019.* Nay Pyi Taw, Myanmar: Central Statistical Organization (CSO).

Morton, J., Pym, R., Hla, T., Sunn, K. and Meers, J. 2013. *Economic analysis of interventions to improve village chicken production in Myanmar.* Preventive Veterinary Medicine 110(3-4): 525-540.

NCC (National Consultative Committee). 2003. *National report on animal genetic resources.* The Union of Myanmar. Available from: https://www.fao.org/3/a1250e/annexes/CountryReports/Myanmar.pdf.

Onyeneke, U., Emenekwe, C.C., Chidiebere-Mark, N.M., Munonye, J.O., Aligbe, J.O., et al. 2020. *Impact of poultry farmers' participation in modern food retail markets on household dietary diversity: Lessons from southeast Nigeria.* Animals 10 (4): 611.

Pandey, V.L., Dev, S.M. and Jayachandran, U. 2016. *Impact of agricultural interventions on the nutritional status in South Asia: A review.* Food Policy 68: 28-40.

Passarelli, S., Ambikapathi, R., Gunaratna, N.S., Madzorera, I., Canavan, C.R., et al. 2020. *A chicken production intervention and additional nutrition behavior change component increased child growth in Ethiopia: A cluster-randomized trial.* The Journal of Nutrition 150 (10): 2806–2817.

Peterson, J., Pearce, P.F., Ferguson, L.A. and Langford, C.A. 2017. *Understanding scoping reviews: Definition, purpose, and process.* Journal of the American Association of Nurse Practitioners 19(1): 12-16.

Pham, M.T., Rajić, A., Greig, J.D., Jan M Sargeant, Papadopoulos, A., et al. 2014. *A scoping review of scoping reviews: advancing the approach and enhancing the consistency.* Res Synth Methods 5 (4): 371-385.

Pritchard, B., Rammohan, A. and Vicola, M. 2019. *The importance of non-farm livelihoods for household food security and dietary diversity in rural Myanmar.* Journal of Rural Studies 67: 89-100.

Pym, R. 2017. *Helping smallholders to improve poultry production. In: Ricke, S.C. (ed.) Achieving Sustainable Production of Poultry Meat, Volume 1: Safety, Quality and Sustainability.* Burleigh Dodds Science Publishing.

Raitzer, D.A., Wong, L.C.Y. and Samson, J.N.G. 2015. *Myanmar's agriculture sector: Unlocking the potential for inclusive growth.* ADB Economics Working Paper Series. Metro Manila, Philippines: Asian Development Bank.

Rammohan, A., Pritchard, B. and Dibley, M. 2019. *Home gardens as a predictor of enhanced dietary diversity and food security in rural Myanmar.* BMC Public Health 19 (1145).

Ruel, M.T. 2003. *Operationalizing dietary diversity: A review of measurement issues and research priorities.* The Journal of Nutrition 133 (11): 3911S–3926S.

Ruel, M.T. and Alderman, H. 2013. *Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition?* Lancet 10 (382[9891]): 536-551.

SAPA. 2021. *Broiler meat market study report. sustainable and affordable poultry for all.* (Available from: https://sapaproject.org/2019/12/20/broiler-meat-market-study-report/) (Accessed 30 March 2021).

Sherman, R., Fenwick, A. and Gibson, T. 2019. *Agricultural extension for uplands: chapter for state agricultural institute national curriculum, Myanmar.* Myanmar Institute for Integrated Development.

Sherman, R.M. 2018. *Sustainable market pathways for feed in upland poultry production and aquaculture in rural Chin State, Myanmar. In: Asemota*, E. & Egan, K. (eds.) Cornell Policy Review.

Stads, G.-J., San, C.C., Khing, A.K., Omot, N., Pham, N.T., et al. 2019. *Myanmar: ASTI country brief.* International Food Policy Research Institute (IFPRI).

Taruvinga, A., Muchenje, V. and Mushunje, A. 2013. *Determinants of rural household dietary diversity: The case of Amatole and Nyandeni districts, South Africa.* International Journal of Development and Sustainability 2(4): 2233-2247.

Tun, T., Kennedy, A. and Nischan, U. 2015. *Promoting agricultural growth in myanmar: a review of policies and an assessment of knowledge gaps.* International Development Working Paper. Michigan State University (MSU).

UNICEF (United Nations Children's Fun). 2016. *Regional report on nutrition security in Asean.* Bangkok, Thailand. (Available from https://www.asean.org/wp-content/uploads/2016/03/Regional-Report-on-Nutrition-Security-in-ASEAN-Volume-1.pdf).

WB (World Bank). 2021. *Employment in agriculture (% of total employment) (modeled ILO estimate).* The World Bank. (Available from https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=MM). (Accessed 08 April 2021).

WFP (World Food Programme). 2019. *Fill the nutrient gap Myanmar: Summary report.* Rome, Italy. (Available from: https://docs.wfp.org/api/documents/WFP-0000115217/download/?_ga=2.227552863.372404133.1623909993-1459795908.1619774406).

WHO (World Health Organization). 2010. *Nutrition Landscape Information System (NLIS) country profile indicators: interpretation guide*. Geneva, Switzerland: WHO Press. https://apps.who.int/iris/handle/10665/44397

Win, T.M. 2012. *Value chain analysis of poultry products in Pathein and Myaung Mya townships.* Myanmar. World Vision. (Available from https://www.fao.org/sustainable-food-value-chains/library/details/ru/c/246128/).

Win, T.M. 2013. *Farming system diagnosis in Lau Tu Region in three townships of Matupi, Hakha and Thangtlang, Chin state, Myanmar*. Myanmar: Country Agency for Rural Development (CAD).

Win, T.T.Z. 2018. *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.* Doctor of philosophy, the University of Queensland.

Win, T.T.Z., Campbell, A., Magalhães, R.J.S., Oo, K.N. and Henning, J. 2019. *Characteristics of livestock husbandry and management practice in the Central Dry Zone of Myanmar*. Tropical Animal Health and Production 51: 643–654.

Win, Z. and Cashin, J. 2016. *Undernutrition in Myanmar: Part 2: A secondary analysis of LIFT 2013 household survey data.* LEARN. (Available from https://landportal.org/library/resources/obl71414/undernutrition-myanmar-part-2-secondary-analysis-lift-2013-household).

Wong, J.T., Bruyn, J.D., Bagnol, B. and Grieve, H. 2017. *Small-scale poultry and food security in resource-poor settings: A review.* Global Food Security 15: 43-52. DOI:10.1016/j.gfs.2017.04.003.

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