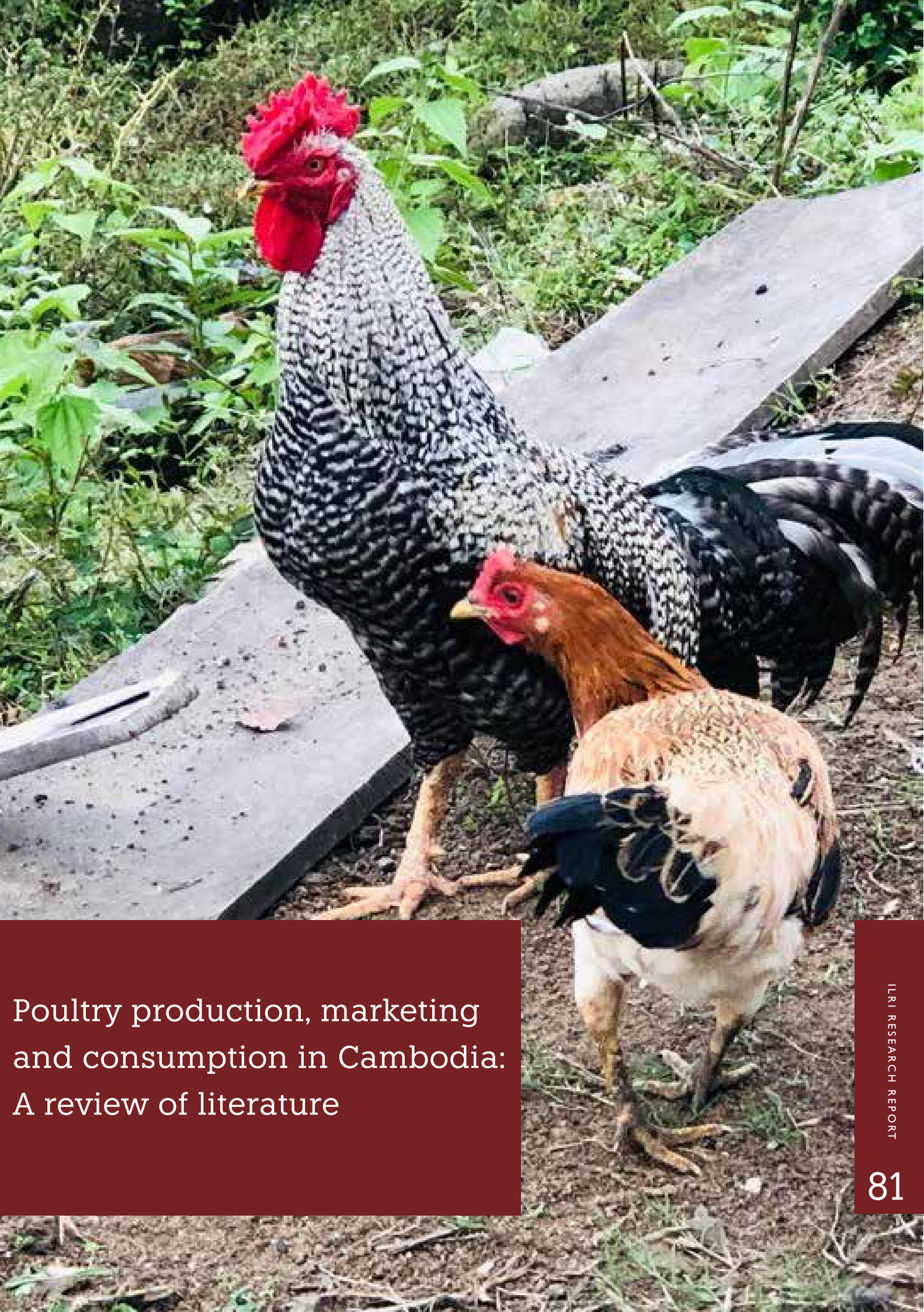

Poultry production, marketing and consumption in Cambodia: A review of literature

ILRI RESEARCH REPORT
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Poultry production, marketing and consumption in Cambodia: A review of literature

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Acronyms and abbreviations

ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
ASFs	Animal-source foods
AsCGG	Asian Chicken Genetic Gains
CARDI	Cambodia Agriculture and Rural Development Institute
DOCs	Day-old chicks
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross domestic product
HPAI	Highly pathogenic avian influenza
ICEM	International Centre for Environmental Management
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
ITC	International Trade Center
MAFF	Ministry of Agriculture, Forestry and Fisheries
MEYS	Ministry of Education, Youth and Sport
NIS	National Institute of Statistics
RGC	Royal government of Cambodia
SNEC	Supreme National Economic Council
UBC	University of British Columbia
USAID	United States Agency for International Development
USD	United States Dollar
WHO	World Health Organization

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Executive summary

The International Livestock Research Institute (ILRI) has an 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'. The project, implemented in Cambodia, Myanmar and Vietnam, aims to test and avail high-producing and farmer-preferred chicken genotypes to increase smallholder production and productivity as a pathway out of poverty. The first phase of the project is this comprehensive literature review that is designed to document the current knowledge base, identify research and development gaps and inform a baseline assessment in the Cambodian context. Fundamental issues addressed include smallholder poultry production and productivity; marketing of poultry products; contribution of smallholder poultry production to household nutrition; economic contribution of smallholder poultry production; agricultural policy and livestock research and finally, conclusions and research opportunities.

Poultry production is the dominant livestock production activity practised by 85% of Cambodia's agricultural households engaged in livestock production. Overall, the poultry population, consisting mostly of chickens and ducks, accounts for 94.4% of the country's total livestock population. There was an increasing trend in the overall poultry population from 2009 to 2017. During this period, chicken and duck populations grew by an average of 4.85 and 20.02% per year, respectively. In 2019/20, there were 40.8 million chickens and 25.1 million ducks, compared to only 2.7 million cattle and 0.6 million pigs in the country. The poultry populations vary across zones, with the highest number of chickens in the Plain zone followed by Tonle Sap, Plateau/Mountain and Phnom Penh zones.

The Food and Agriculture Organisation of the United Nations (FAO) reported contrasting growth trends in the volumes of chicken and duck meat produced from 2000–19. Chicken meat production decreased by 0.20% per year, while duck meat production increased by 2.37%. However, chicken egg production increased by 2.73% during the same period while egg production from other birds, including ducks, was stagnant. Cambodia has one of the lowest poultry meat and egg consumption rates within the region and globally. Moreover, overall consumption rates of poultry meat have been declining. The average poultry meat consumption declined from 2.14 to 1.75 kg/capita per year between 2001 and 2016. However, consumption increased to 2.46 kg/capita per year in 2018, which was still lower than the global, regional and sub-regional averages of 15.55, 10.08 and 13.57 kg/capita per year, respectively. Similarly, the average egg consumption was about 1.2 kg/capita per year in 2018, while the global and regional averages were 9.68 and 10.08 kg/capita per year, respectively.

Poultry production systems in Cambodia can be classified into traditional/backyard, semi-intensive small or medium scale and intensive large-scale industrial. About 93% of poultry production is under the traditional/backyard system with small flock sizes that are usually less than fifty birds per household. The productivity of this system is very low, although it still contributes significantly to poverty reduction and food security.

The chicken is the most important and most common poultry species for smallholder farmers in the country. Chicken genotypes kept under a smallholder production system include indigenous/local breeds (ecotypes), hybrids (commercial strains) and crossbreds (composites). Among the indigenous/local breeds are Kandong, Sampov, Kragnas, Skoeuy,

Samley, Bantam Kork, Prochul, Che and Khmao. Sampov accounts for the highest proportion of chickens in the country. The indigenous breeds are better adapted to the local environment and are suitable for a low-cost production setting. The productivity of indigenous chicken breeds is generally considered to be low.

Diseases, chicken mortality, high feed price, limited technical knowledge, extreme weather, limited water availability during the hot season, the poor genetic potential of existing local breeds and small landholdings are the main poultry production constraints identified by most smallholder producers. Smallholder producers' practice within-breed selection to improve the performance of their flocks focusing on different traits such as weight, body size, body conformation and plumage colour. Despite their low productivity and slow growth, smallholder producers still prefer indigenous breeds for their adaptability to the harsh tropical environment, reproductive characteristics (ability to incubate eggs), good sensory properties of meat and eggs and other cultural and social values.

Most smallholder producers sell eggs and live chickens. However, since local breeds have low egg productivity, the majority of farmers produce and sell live chickens rather than eggs. A larger number of smallholder producers participate in the marketing of duck eggs compared to chicken eggs. However, farmers face numerous marketing challenges that include limited market power, limited access to market information, price fluctuation, diseases, loss of chickens during transportation, inadequate transportation facilities, hot climate, seasonal and unbalanced demand and supply, and birds' poor quality. Farmers close to markets tend to keep a greater number of birds than those that live far from markets.

In rural areas of Cambodia, household diet diversity remains low as food security is usually associated with improved production and productivity of grains, mainly rice. The existing contribution of poultry meat and eggs to household nutrition and diet diversity is not adequate. Consequently, undernutrition in children and other vulnerable groups is a major health and development concern in Cambodia. Indeed, in the previous few decades, the proportion of stunted children in Cambodia was higher than the sub-regional, regional and global averages. Moreover, the prevalence of anaemia among children aged 6–59 months and women of reproductive age (15–49 years) was also higher than the regional and global averages.

A number of empirical studies have documented the significant socio-economic and nutritional contribution of poultry production in Cambodia. Most rural households in the country use poultry products for home consumption and income generation. The income generated from poultry production is used to purchase household goods (food, clothing and shelter), pay for school fees and medical expenses, and invest in other economic activities. Poultry production is the second-highest source of household income for most rural households after rice production. It has a vital role in empowering women, creating jobs, reducing poverty and enhancing equity in the rural and agricultural sectors of the country.

The government of Cambodia has implemented various agricultural development policies and strategies in the last few decades. The agricultural sector has been the priority sector in development policies and strategies. However, the productivity of this sector remained low due to multiple constraints. Investment in agricultural research is generally considered low and biased towards crop research. As a result, the livestock sector performance has fallen behind that of neighbouring countries, leaving the country highly dependent on imported animal products. While the productivity of smallholder poultry production is low, its indisputable multidimensional contribution to livelihoods demands intensive integrated research and development efforts to overcome challenges and exploit existing opportunities. A range of interventions can be considered, such as introducing fast-growing and locally adapted commercial poultry breeds; improving the productivity of indigenous genotypes through selective breeding; enhancing farmers' management and entrepreneurial skills; organizing producers for collective actions; establishing a sustainable supply of locally available and low-cost inputs such as feed and drugs through public-private partnerships; improving smallholder farmers' access to market and market information and enhancing poultry products marketing infrastructure and facilities.

The higher preference for meat and eggs from indigenous chicken breeds compared to commercial breeds in Cambodia means the production and productivity of indigenous breeds should be enhanced. Higher proportion of households engaged in smallholder poultry production, existing gaps in meat and egg production and productivity, and growing demand for poultry products consumption entail the need for comprehensive research and development interventions. Research interventions can adopt the following two main approaches, improving the traditional management practices and initiating genetic improvement programs. Improved management practices such as better feeding, health, and housing play a significant role in enhancing the production and productivity of existing household breeds. Genetic improvements efforts may focus on improving the genetics of existing breeds or introducing locally adapted and farmers-preferred improved commercial breeds. This may include integrating sustainable chicks and inputs delivery models, developing innovative business models, and building households behaviour on improved production and consumption practices. Such approaches would have a considerable contribution to the sustainability of smallholder chicken production in the country

1 Introduction

Agriculture plays a vital role in the Cambodian economy. It contributed 26.3% of the country's gross domestic product (GDP) in 2016 (MAFF 2017). A large proportion of agricultural households keep livestock, one of Cambodia's most important agricultural activities that contributed 11.96% of the GDP from the agricultural sector in 2016. It is the third most important contributor to agricultural GDP after crop production and fisheries. According to the 2013 census, 75% of agricultural households kept livestock, and 85% of these households were engaged in poultry production (NIS 2015b). Like in other Asian countries, poultry production activities include meat and egg production from different species such as chicken, ducks, quails, turkeys and other domestic animals (NIS 2015b). Chicken is the most common poultry species raised by most agricultural households (NIS 2018). For instance, in 2019, 98.0% of all poultry producers reared local chickens, while only 18.1% reared local ducks (NIS 2020a). This shows the important role that chickens play in the livelihoods of agricultural households.

The poultry production sector consists of backyard/traditional, semi-intensive and intensive or commercial systems. However, the backyard/traditional production system is the dominant one in the country. Indeed, the number of commercial poultry farms is far less than the number of backyard/traditional production units. According to Sun (2018), about 85% of the chickens are produced by smallholder farmers in the backyard/traditional or semi-intensive production systems. This production system significantly contributes to the livelihoods of most rural and urban households. It is a source of cheap protein and income for most resource-poor rural and peri-urban households. However, this sector's overall production and productivity has remained low due to various production and marketing constraints.

Demand for poultry products has significantly increased in the last few years and is projected to continue the upward trend in the next few decades (ICEM 2014, Sun 2018). Given the low production and productivity of the sector, greater demand for poultry products will continue to widen the supply-demand gap in the coming decades. The poultry production sector in Cambodia is characterized by multiple production, marketing and consumption challenges. Addressing existing production and marketing bottlenecks requires integrated research and development interventions by government and non-governmental organizations. To this end, the International Livestock Research Institute (ILRI) has initiated a Research for a Development project to improve the country's smallholder chicken production and productivity. This project starts with this comprehensive literature review to understand and document the current knowledge base and identify research and development gaps. The review quantifies information on current smallholder chicken production and productivity, husbandry practices, producers' preferences, consumer demands and the socio-economic status of poor smallholder farmers in the country. Information on poultry production and marketing activities, consumption of poultry products, the nutritional and economic contribution of poultry production and research and development efforts in the country is synthesized. The review starts by outlining trends in overall poultry production and consumption. This is followed by an exploration of existing practices in smallholder chicken production systems in the country. Finally, the review highlights the nutritional and economic contribution of smallholder poultry production, agricultural policies, and major livestock research and development opportunities that can enhance the production and productivity of the sector in the country.

2 Review approach and data sources

The review approach we adopted can be considered a scoping review, as it focuses on exploring the breadth of available evidence and informing proposed research efforts in the country's (Peterson et al. 2017, JBI 2020). This approach enabled the synthesis of information on broader topics related to poultry production, marketing and consumption, and the identification of existing research and development gaps in the country (Pham et al. 2014). Diverse sources, such as published and grey articles, research reports, national and international databases, books and policy documents, were consulted for this review. Time-series data from different sources such as the National Institute of Statistics (NIS), the FAO, and the International Trade Centre (ITC) were used to explore national-level trends on production, consumption, and marketing issues. Empirical evidence on poultry production, marketing and consumption from experimental and non-experimental studies was also synthesized at the household level.

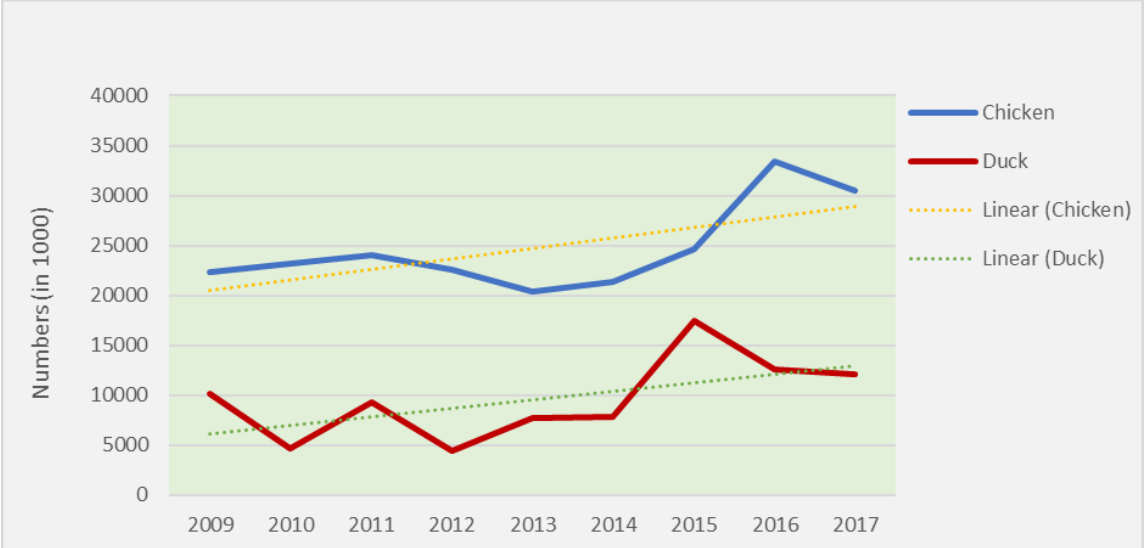
3 Overview of poultry production and consumption

3.1 Trends in poultry production

Poultry is the most common livestock species in most agricultural households in Cambodia (NIS 2020b). For instance, during 2019/20, the country had 40.8 and 25.1 million chickens and ducks, respectively. The number of cattle and pigs in the same period was 2.7 and 0.6 million, respectively. The combined poultry population (chickens, ducks and quail) accounts for about 94.4% of the total livestock population. Based on a series of reports by the Cambodia Socioeconomic Survey (CSES), Figure 1 presents changes in the population of chickens and ducks from 2009–17. During this period, chicken and duck populations grew by an average of 4.85 and 20.02% per year, respectively. Despite the lower average population growth rate, the relative change in the chicken population was significant. When the total number of chickens in 2009 was compared to that in 2017, a 36.65% increase was recorded. The average chicken population was 2.6 times that of the average duck population from 2009 to 2017. This confirms that chicken is the dominant poultry species in the country, with significant potential socio-economic and nutritional contributions to rural and agricultural households.

The total chicken and duck population fluctuated considerably during the nine years presented in Figure 1. There was an increase in chicken population from 2009 to 2011, followed by a decrease until 2013. After 2013, the number of chickens increased significantly and peaked in 2016. Substantial growth in chicken (33.5%) and duck (107.7%) populations was observed from 2017 to 2020. Greater fluctuations in population size were apparent in ducks than in chickens. After 2012, the total duck population growth surged, peaking in 2015.

Figure 1: Trends in total poultry population in Cambodia (2009–17).

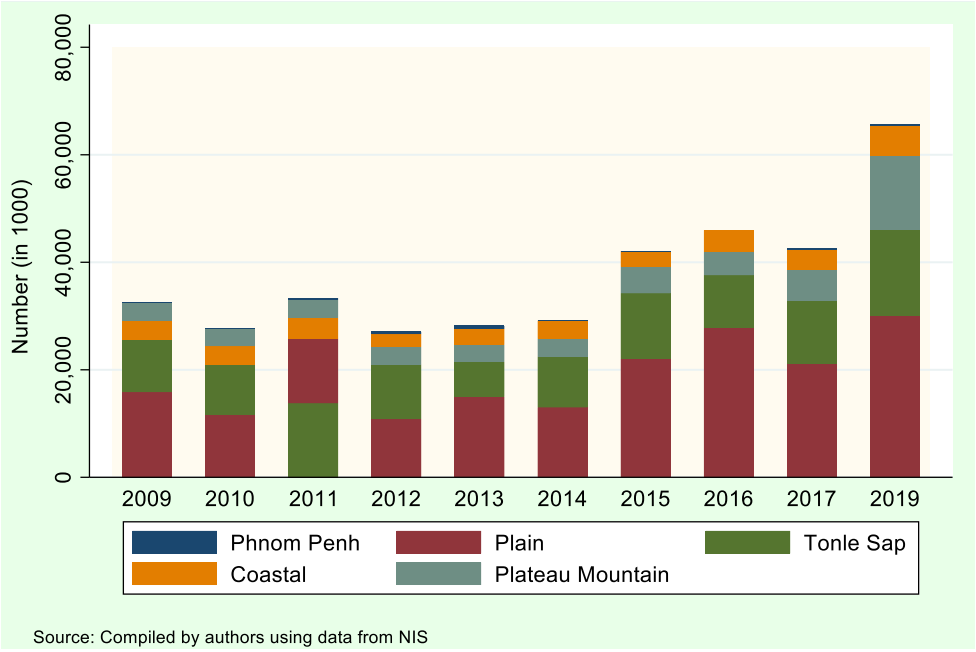


Source: Compiled by authors using data from NIS (2018)

3.2 Geographical distribution of poultry production

Poultry production is an integral part of agricultural activities in all country zones (NIS 2020a). However, there is significant variation in the volume of poultry production across different zones. Evidence from NIS shows that the highest number of poultry are produced in the Plain zone, followed by Tonle Sap, Plateau/Mountain and Phnom Penh zones (Figure 2). From 2009–19, total poultry production in the Plain and Tonle zones was about 48.0 and 28.96% of the overall production, respectively. The contribution to overall poultry production in the Plateau/Mountain Coastal and Phnom Penh zones was 12.97, 9.53 and 0.55%, respectively. With the exception of the Phnom Penh zone, overall poultry production increased in all the zones.

Figure 2: Poultry production in different zones of Cambodia.



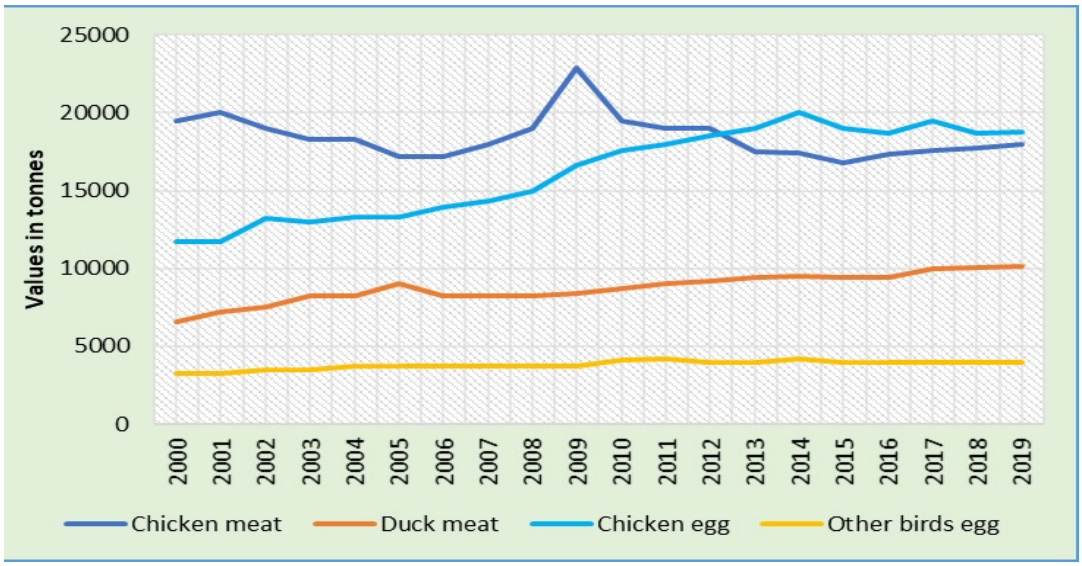
Source: Compiled by authors using data from NIS

There was significant variation in the number of livestock and poultry producers in different provinces of Cambodia. This could have been due to variation in population density, environmental factors, agro-ecological conditions, production resources and marketing opportunities. According to the FAO (2009a), the poultry production system in some provinces is associated with household wealth status. Poor households mainly practise traditional chicken and small-scale duck production in rural areas, while middle-income households practise medium and large-scale systems. Better-off households practise commercial chicken farming in suburban and urban areas. Variation in total chicken production may indicate the role of the sector in households' socio-economic activities and the need for aligning research and development efforts accordingly.

3.3 Meat and egg production

Meat and eggs are the main poultry products produced in Cambodia. In 2019, the country produced 17,979 and 10,145 tonnes of chicken and duck meat, respectively (Figure 3). In addition, 18,720 and 4,000 tonnes of hen and other birds' eggs were produced, respectively. According to the FAO estimates, there was a downward trend in total chicken meat production from 2000–19. On average, the amount of chicken meat produced decreased by 0.20% during the above period. The highest volume of meat was recorded in 2009, while the lowest amount was recorded in 2004/05. In the same period, average duck meat production increased by 2.37% per annum. Unlike chicken meat, chicken egg production grew by an average of 2.73% annually. Egg production from other birds was mostly stagnant over the years in question.

Figure 3: Trends in poultry meat and egg production (2000–19).

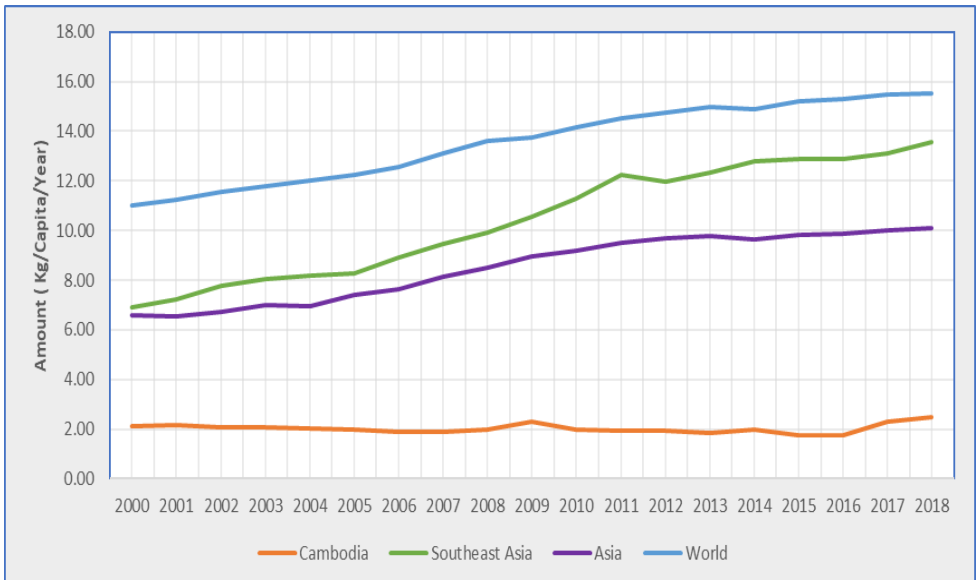


Source: Compiled by authors using data from the FAO (2021)

3.4 Trends in poultry products supply and consumption

There was a downward trend in poultry meat's average annual per capita consumption (Figure 4). From 2000 to 2018, the overall average poultry meat consumption was 2.02 kg/capita per year. Unlike in other countries, the average annual per capita poultry meat consumption gradually declined from 2.14 kg/capita per year in 2000 to 1.75 kg/capita per year in 2016 before rising to 2.46 kg/capita per year in 2018. During the same year (2018), the average global, regional and sub-regional consumption was significantly higher at about 15.55, 10.08 and 13.57 kg/capita per year, respectively. Similarly, the average poultry meat consumption in neighbouring countries, Thailand, Laos and Vietnam, was about 12.36, 5.8 and 15.89 kg/capita per year, respectively. This shows that poultry meat consumption in Cambodia is significantly lower than average global, regional and sub-regional consumption levels. The lower level of consumption could be due to several factors, including a lower level of chicken production and productivity and other cultural and religious aspects.

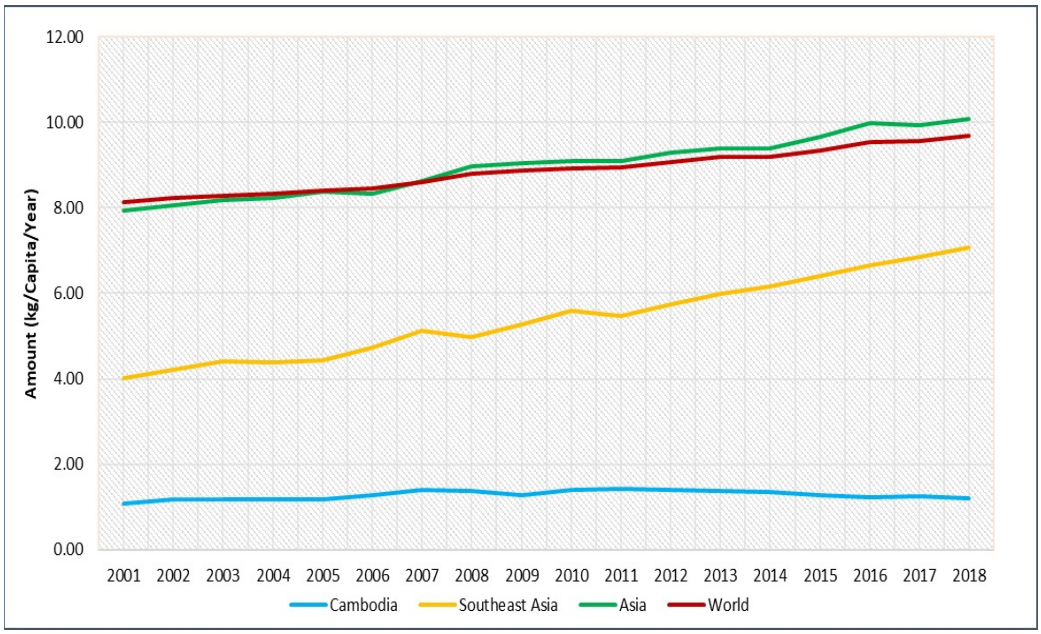
Figure 4: Consumption of poultry meat in Cambodia and other countries (2000–18).



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

In 2001–18, egg consumption in Cambodia was lower than global and regional averages (Figure 5). In 2018, average egg consumption was about 1.2 kg/capita per year, while the global and regional average consumption was 9.68 and 10.08 kg/capita per year, respectively. The average consumption in Thailand and Vietnam was 12.06 and 5.13 kg/capita per year, respectively, which was significantly higher than in Cambodia during the period in question. Cambodia's overall egg consumption remained below 2 kg/capita per year from 2001-18, in contrast to the upward trend in global and regional consumption. The lower and static consumption rate in Cambodia suggests the need for sustainable transformation of the poultry sector through innovative research and development approaches such as introducing high yielding but resilient genetics, improved management and commercializing small and medium-scale production systems.

Figure 5: Consumption f poultry eggs in Cambodia and other countries (2000–18).



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

Cambodia imports poultry meat from countries such as China, Thailand, Brazil and others. As shown in Table 1, China and Thailand exported the most meat to Cambodia between 2016 and 2020 (Table 1). However, during this period, there was a significant increase in imports from Brazil. Compared to 2016, the value of poultry meat imports in 2020 grew by 169.4% that may indicate a growing demand for poultry meat in the country.

Table 1: Value of poultry meat (United States dollar, USD) imported into Cambodia

Origin	Value of imports (000s)				
	2016	2017	2018	2019	2020
China	306.0	497.0	590.0	570.0	4,918.0
Thailand	2,773.0	2,406.0	3,679.0	2,999.0	2,660.0
Brazil	0.0	14.0	27.0	343.0	759.0
Others	53.0	38.0	94.0	502.0	100.0
World	3,132.0	2,955.0	4,391.0	4,413.0	8,438.0

Source: Compiled by authors using data from ITC (2021)

3.5 Poultry production systems

Like in other developing countries, poultry production in Cambodia can be classified into several systems. Heft-Neal et al. (2009) classified poultry production into traditional small-scale, semi-intensive small/medium scale commercial and medium/large scale intensive industrial. On the other hand, Burgos et al. (2008) classified poultry production into traditional, small-scale, extensive backyard/garden; semi-intensive, small to medium scale, market-oriented, commercial and intensive, large scale industrially-integrated systems. These classifications are commonly used in most developing countries and have been adopted with slight modifications in this review. For simplicity, the production systems have been renamed traditional/backyard, semi-intensive small/medium-scale and intensive large-scale industrial. The traditional/backyard production system mainly includes traditional smallholder producers who raise a small number of birds in their backyards. The semi-intensive small/medium scale production includes market-oriented small to medium scale producers that use improved production methods and marketing systems compared to the traditional/backyard production. The intensive industrial large-scale output mainly refers to specialized commercial farms specializing in broiler chickens, layers, ducks or breeding stock (Frontières 2005). This sector integrates input and service providers, including chick and feed suppliers, veterinary products suppliers, veterinarian and para-veterinarians and credit service providers. In December 2018, the General Directorate of Animal Health and Production (GDAHP) classified commercial chicken production into small, medium and large farms. Each farm may contain different poultry species such as layers, boilers and breeding stocks.

3.5.1 Traditional/backyard production

The traditional/backyard is the predominant poultry production system in Cambodia. This system produces more than 90% of the poultry eggs and meat in the country (Burgos et al. 2008). Producers in this category use mainly indigenous breeds with minimal inputs while the use of improved or exotic breeds is limited (FAO 2009b). Most smallholder producers prefer local breeds over exotic breeds because they are adapted to the local environment, and consumers prefer their meat (Burgos et al. 2008). Most agricultural households keep 4–5 local hens with limited feeding and housing. The size of flocks is mainly constrained by the capacity of households to provide additional feeds (FAO 2009c). According to Kerkhove (2012), about 93% of the poultry production in Cambodia is characterized by backyard farming with a very small flock size per household. A recent national-level survey indicated that 91% of the households raising poultry had 1–49 birds on average, while only 0.8% of the households had more than 200 birds each (NIS 2020b).

Producers traditional/backyard production system use locally available resources for production. The primary foundation/replacement stocks are derived from their own flock and purchases from neighbouring producers or local markets (FAO 2009b). Farmers in this system rely on the natural capacity of their hens to incubate and hatch eggs for sustained production. However, in the past few years, some farmers have started to use small-scale hatcheries to incubate local chicken eggs to supply chicks to poultry producers. Hatcheries get eggs either from farmers' own birds or breeding farms. As a result, there is a continuous supply of replacement stock throughout the year in this production system. Even though feed obtained from scavenging is the primary nutrient source, producers provide supplementary feeds such as household waste, dried or fermented rice and vegetable waste (Sun 2018). The supplemental feed is usually offered to adult birds once or twice a day, while commercial feed may be given to chicks. Most of the feed requirements are expected to be met by scavenging on locally available feed resources.

Most smallholder producers do not build separate chicken houses due to limited resources, fear of theft, and preference to keep chickens with other animals (FAO 2009c). Since producers in this system have limited financial means to invest, they usually build simple housing in the form of night shelters. Sometimes birds can also spend their nights in trees and natural sheds. Producers use only a small amount of money to buy inputs such as day-old chicks and supplementary feeds. Unlike the other production systems, producers in this system do not provide adequate vaccination to their chickens due to limited access to vaccines, inadequate knowledge and smaller flock sizes.

Smallholder producers in this system produce live birds and eggs for home consumption and income generation. Both consumption and marketing of poultry products target festival seasons from January to April and restocking usually starts after the hot season ends in July. Producers also raise fighting cocks either for sale or to participate in cockfighting. Producers involved in cockfighting are usually middle-income households. According to the FAO (2009c), a fighting cock can be sold from 30–1,500 United States dollars (USD) based on the ability of the cock to fight and defeat opponents.

3.5.2 Semi-intensive small/medium-scale production

This production system started in the 1990s as a transition between traditional/backyard production and intensive large-scale industrial production systems. Flock sizes in this system range from 50–2,000 chickens (Burgos et al. 2008), and the producers are usually found around urban areas (McNamara and Dahl 2016). In this production system, producers use improved husbandry practices such as better feeding and housing as well as improved breeds. Producers are usually market-oriented compared to those in the traditional/backyard production system. In addition to feeds obtained from scavenging, producers also provide locally available feed resources, commercial feeds and feed additives to their chickens.

Day-old chicks (DOCs) from improved strains (obtained from local hatcheries) and local breeds (obtained from natural incubations or local markets) can be used as foundation and replacement stocks. Better housing, made from locally available materials, is used to shelter birds during the day and at night. The housing may be permanent or temporary. Compared to the traditional production system, semi-intensive producers use better biosecurity measures for disease prevention, treatment and management. The egg and meat productivity of birds in this system is higher than in the traditional/backyard production system. For example, a broiler can be grown within 70 to 90 days with lower mortality rates (Burgos et al. 2008) in the semi-intensive production system.

3.5.3 Intensive large-scale industrial production

Cambodia's intensive large-scale industrial production system also has a fairly recent history, having started between 1995 and 2000 (Frontières 2005). Farms under this category may include commercial breeding farms, commercial hatcheries, broiler and layer farms that supply meat and eggs to main cities in the country (Burgos et al. 2008). Commercial farms under this category usually have 10,000–15,000 birds, each with automatic housing and feeding systems. The farms are capital and resource-intensive, with higher levels of investments in feeding, animal health, housing, maintenance and biosecurity resulting in higher levels of flock productivity.

Farms in this production system use commercial line breeds and may be integrated with other farms or operate independently. The integrated farms receive DOCs, feeds, vaccinations, drugs and technical advice from the integrator. The farms provide the infrastructure and labour and take responsibility for raising the chickens for delivery to the integrator. Farms without contracts buy DOCs from local hatcheries or importers and independently provide commercial feeds and other inputs. The productivity of farms under this system is higher than in the traditional/backyard and semi-intensive systems described above. For instance, the production cycle for broiler farms is 42–45 days (about six weeks), and birds weigh 1.75–2.0 kg at the end of the cycle (Burgos et al. 2008). On average, a layer produces 225–275 eggs per year that can be marketed for home consumption or as inputs for agro-industries. While the sale of meat is the primary source of income for broiler farms, layer farms generate revenue from the sale of eggs, culled hens and manure. Breeds raised in this system are mainly obtained from foreign-owned hatcheries in Thailand, China and Vietnam. Farms in this production system get replacement stock either from hatcheries (DOCs) or grower farms (farms that grow DOCs for a specific number of days).

4 Smallholder chicken production and productivity

4.1 Type of chicken breeds

Chicken breeds in Cambodia can be categorized into indigenous/local breeds, hybrids (commercial strains or synthetics), partial hybrid, and crossbreds (composites) (Bun and Brewster 2015, Sun 2018). Cambodia has different indigenous breeds (ecotypes): Kandong, Sampov, Kragnas, Skoeuy, Samley, Bantam Kork, Prochul, Che and Khmao (Burgos et al. 2008, MEYS 2013). Indigenous breeds are preferred for their adaptation to the local environment and the low production cost in terms of feed, vaccination and housing (Sun 2018). Among the indigenous breeds, the Sampov is the most common breed in the country. Very few of the smallholder farmers use exotic breeds (FAO 2009b) in preference of these indigenous breeds. Available exotic strains include Plymutroot Island Papi Marok and Australorp for meat and ISA Brown leucone for eggs. While hybrids are mix of different pure breeds, partial hybrids refer to three-way crosses between local breeds and hybrids (Bun and Brewster 2015). The exotic strains and hybrids are usually imported and used either for egg or meat production.

4.2 Chicken management

Smallholder producers adopt different chicken management practices based on their production objectives, type of production system and available resources. Feeding, housing, health and biosecurity are the main management aspects that have a significant impact on the productivity of birds. Despite scavenging being the most important source of chicken feed, smallholder chicken producers also provide supplementary feeds sourced from either their farms or purchased from local markets. The main feed types include paddy, broken and white rice, rice bran, human food waste, insects and worms, grass, leaves and commercial feeds (Heft-Neal et al. 2009).

According to the FAO (2009b), data from five different provinces show that while 2.0–23.6% of the sampled producers house their chickens during the day and at night, 62.5–79.2% of smallholder producers house their chickens only during the night. Smallholder producers usually build houses from locally available materials such as mud bricks or bamboo and tree branches (Heft-Neal et al. 2009). The type of housing system tends to depend on the production system. As indicated above, smallholder chicken producers under semi-intensive production use better housing systems than producers under the traditional/backyard production system (Heft-Neal et al. 2009).

Poultry diseases and parasites are major constraints in the smallholder production system. Common diseases include Newcastle disease, avian influenza, fowl cholera and fowl pox (ICEM 2014). A smaller proportion (34%) of households use available veterinary facilities, and a few vaccinate their chickens (FAO 2009b). According to Melara et al. (2018a), 95% of farmers have never vaccinated their poultry against common diseases like Newcastle, fowl pox and cholera. Only 3% of the sample respondents practised biosecurity measures. As a result, mortality seems to be the major contributor to losses

experienced by chicken producers in the country. For example, the average number of losses per holding in 2019 was 17, while the average number of chickens consumed and sold in that year were 11 and 12, respectively (NIS 2020a). Higher disease incidence affects the production and productivity of the sector (ADB 2021). The average survival rate for chicks up to six months of age was about 63–75% at the smallholder level. Lack of skills and knowledge, shortage of capital and limited access to health services are the major reasons for the low adoption of good animal health practices and limited application of biosecurity measures.

4.3 Chicken productivity

In Cambodia, empirical evidence on the productivity of chickens is inadequate. However, available research shows that the productivity of indigenous chickens under the smallholder production system is considered low due to genetic and management-related factors. According to the FAO (2009b), a hen starts laying eggs between 5.9 and 6.3 months and has 3.6–4.0 production clutches per year with an average of 11.6–12.3 eggs per clutch. The average body weight of mature indigenous chickens is also smaller compared to improved or commercial breeds. Based on a sample of birds from five different provinces, mature male and female chickens weigh on average 1,719 and 1,494 g, respectively. Another study also documented that the average weight of indigenous chickens is 1,200 g (FAO 2009d). Other value chain actors, such as traders, believe that local chickens have smaller body sizes and weights (Bun and Brewster 2015).

4.4 Breed selection and trait preferences

Smallholder producers in the country use different approaches to improve the productivity of their flocks. They replace birds with lower productivity with chicks produced through natural incubation or purchased from local markets and neighbouring farmers (FAO 2009b). When selecting the best-performing birds from their flocks, farmers consider a physical appearance, body size, egg productivity, mothering ability, feather, shank and eye colour, skin moisture, health, agility and scavenging ability (FAO 2009c, FAO 2009b, MEYS 2013). According to the FAO (2009b), body weight and the number of eggs are the major traits used by smallholder farms during bird selection. In addition to phenotypic characteristics and availability, producers also consider the preferences of the local population and the adaptability of birds to the environment. Compared to improved or exotic breeds, most rural producers prefer local chickens because they have a high market demand. The high demand is due to the good sensory attributes of their meat as well as their ease of adaptation to local weather conditions (Bun and Brewster 2015, Sun 2018).

4.5 Major production constraints

Chicken mortality, high feed price, limited technical knowledge, bad weather conditions (hot climate), limited access to water during the hot season, and inadequate land size are the main production constraints raised by most smallholder producers in Cambodia (FAO 2009c, Bun and Brewster 2015, Melara et al. 2018b, ADB 2021). Highly Pathogenic Avian Influenza (HPAI) has posed a significant challenge to the commercial poultry sector (Burgos et al. 2008). Increasing feed prices and limited availability of land for chicken housing and scavenging have been reported as major challenges in peri-urban and settlement areas. Hot climatic conditions coupled with inadequate access to water increases disease incidence and result in significant losses of birds. Limited access to health services, poor genetics, inadequate disease prevention management, high seasonal disease outbreaks and limited feeding and housing practices are also among the main constraints (UBC and HKI 2018, ADB 2021). Social inequality, age and gender of producers are additional production constraints (FAO 2009c).

The inadequate supply of poultry meat and eggs could be related to the poor genetic potential of indigenous breeds in the country. Low egg and meat productivity have been reported for local breeds kept in traditional/backyard production systems (FAO 2009b). Other critical challenges include the stigma associated with certain physical attributes of chicken ecotypes or species (e.g., distaste for white chickens and geese); discrimination of producers on the basis of gender and age, which negatively impacts the adoption of commercial production practices and theft of live birds. Older people have limited participation in livestock production activities because they tend to be more committed to religious activities. Overcoming the existing poultry production challenges demands interventions that enhance the productivity of birds, increase overall production, empower women and create awareness at the community and national level.

Research and development efforts that aim to improve the productivity of existing breeds may include the introduction of locally adapted commercial genotypes, developing crossbreeds from commercial and indigenous genotypes, introgression of genes from commercial genotypes via backcrossing or cockerel exchange programmes and selecting better performing indigenous genotypes (Pym 2013). Given the higher preference for indigenous breeds in Cambodia, initiating improvement programs for these breeds may have long-term positive outcomes in the sector (Padhi 2016).

5 Marketing of poultry products

5.1 Overview of the poultry market

Marketing of poultry products is an integral activity in traditional/backyard, semi-intensive and intensive production systems. For traditional/backyard producers, the sale of live chickens is the third most common reason for poultry exiting the flock after mortality and slaughtering (NIS 2020a). However, for ducks, live sales are the most common cause of bird exit. In 2019, the average number of indigenous live chickens and ducks sold per holding was 11 and 24, respectively. Despite a smaller proportion of duck producers, the average number of ducks sold per holding was higher than for chickens. Despite the proportion of holders who reported producing eggs from chicken and ducks being less than 2%, about 55 and 53% of indigenous chicken and duck eggs, respectively, were sold to generate income. Due to low egg productivity in indigenous chickens, smallholder producers tend to produce and market live chickens rather than eggs. Higher income is generated from the production and marketing of duck eggs compared to chicken eggs. For instance, according to NIS (2020b), the highest proportion of revenue was generated from duck product sales compared to chicken eggs.

According to market officials and traders, most of the live chickens sold are local breeds, while most eggs are from improved strains (FAO 2009a) . As a result, the largest proportion of live chickens sold in the market comes from smallholder producers. The unit price of local chickens is higher than that of commercial broilers (Burgos et al. 2008). However, in some markets, chicken meat from improved breeds may account for the largest proportion of sales than local breeds (Bun and Brewster 2015). Consumers in the cities prefer birds with yellow skin and shank. Chickens with dark meat and bones are mainly consumed during special occasions like weddings to recover from sickness or occasional family parties (FAO 2009a).

Eggs in the urban retail markets are supplied from commercial farms within Cambodia and neighbouring countries such as Thailand and Vietnam. Rather than smallholder producers, commercial farms are the primary source of eggs and meat for direct purchase by the urban population, restaurants and hotels (FAO 2009a). As already discussed above, this could be associated with low egg production as well as a higher preference for the live bird than egg production by smallholder producers.

Like in other developing countries in Africa and Asia, the marketing of poultry products shows seasonal variability in Cambodia. Households usually fatten chickens to sell during the Chinese new year in February and Khmer new year in April (Bun and Brewster 2015). During these two periods, the price of chicken is significantly higher than usual. Due to the higher demand for poultry products during these periods, supply is always inadequate. For instance, a study conducted by Bun and Brewster (2015) shows that both smallholder producers and wholesalers reported a significant supply-demand gap in their areas. In some areas, only better-off households consume chicken during the busiest rainy season.

Marketers of poultry products could be classified as 'licensed' and 'unlicensed' sellers (FAO 2009a). The 'unlicensed sellers' are marketers who occasionally sell their poultry products or traders that are not registered to sell poultry products

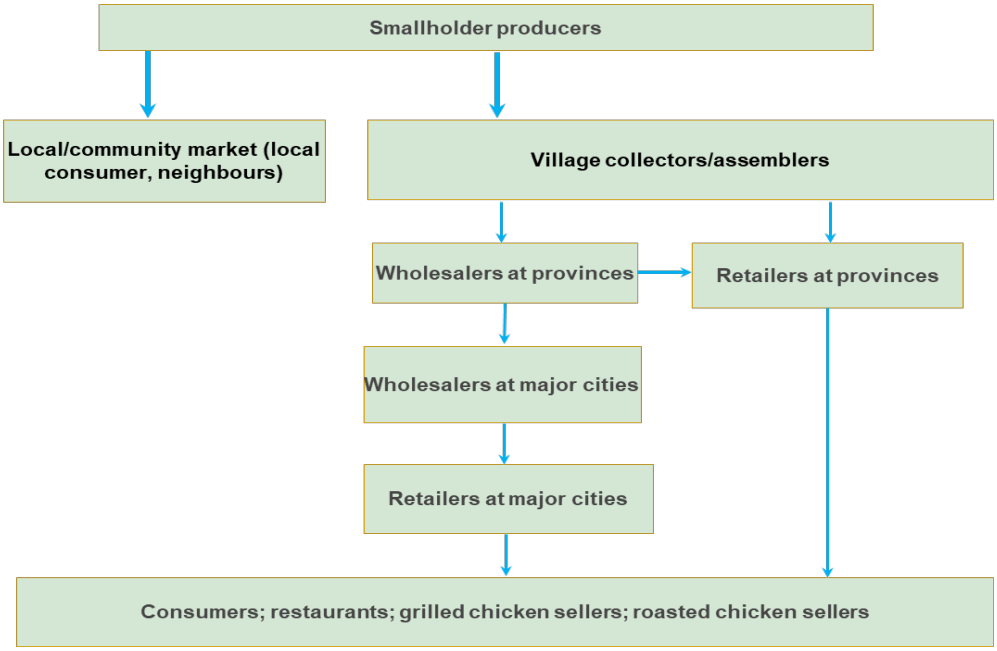
by the marketing authorities. The 'licensed sellers' pay monthly taxes and annual license fees in addition to daily selling fees. Both licensed and unlicensed traders sell live birds, slaughtered birds and eggs in the market. Poultry markets can be publicly or privately owned (FAO 2009a). Sometimes local investors build private markets and manage marketing activities based on the agreements made with the government. A report by ADB (2021) shows that infrastructure in most fresh agricultural markets, including poultry products, is outdated, overcrowded, unhygienic and requires major renovation or relocation.

5.2 Smallholder poultry products market chain

As indicated above, most smallholder producers participate in the marketing of live birds more than eggs. They market their poultry products in a variety of ways to different buyers (FAO 2009b). Buyers of poultry products may come from the same village, commune, district, province or other provinces and hence the products can be sold at the farm gate, local market, or collection points. Usually, smallholder producers sell products to village collectors, traders or other buyers such as individual consumers or fellow farmers in the village. By and large, the country's smallholder poultry products' marketing channels may be dual as shown in Figure 6. In the first marketing channel (local/commune markets), producers sell their products in the local market directly to buyers such as local consumers, fellow farmers and local processors (FAO 2009b, Bun and Brewster 2015). According to Bun and Brewster (2015), about 20% of the output is sold through this marketing channel.

The second marketing channel primarily involves the selling of poultry products to village collectors or assemblers/ traders. This is the most important marketing channel for smallholder poultry production in the country. Various studies have documented that the largest proportion of live birds are also sold through this channel. For instance, a study conducted by Bun and Brewster (2015) showed that 80% of the poultry products in Pursat and Kampong Chhnang provinces are marketed through this channel. On average, collectors usually buy birds from four to eight villages per day at farm gates or sometimes at collection points. Collectors/traders in this channel can be categorized into bicycle, motorcycle and car traders. The bicycle traders collect live birds from the villages and sell them to motorcycle traders who then sell them to car traders. Finally, the car traders sell the birds to wholesalers and retailers in the provincial and city markets who sell to supermarkets, open market retailers or wholesalers in major city markets. These retailers, in turn, sell to individual consumers, restaurants and grilled and roasted chicken sellers.

Figure 6: Marketing channels for smallholder poultry products.



Source: Adopted from Bun and Brewster (2015)

5.3 Pricing of poultry products

The price of poultry products depends on various factors such as breed, selling season and quality attributes of birds or eggs. Due to the higher demand for local chicken products, their prices are higher than that of hybrids or crossbreds (Sun 2018). As indicated above, the selling season has an important effect on the price of poultry products. The price of poultry products is determined through negotiations between smallholder producers and the various buyers. However, smallholder farmers have limited bargaining power due to inadequate access to markets and market information (Sun 2018). As a result, they usually receive lower prices than other producers. Sellers in some markets use weighing scales to determine the price of live birds and meat. Traders in some poultry markets make formal or informal (verbal or written) agreements with suppliers of poultry products (FAO 2009a, Heft-Neal et al. 2009).

5.4 Major marketing constraints

The main marketing related constraints in Cambodia include limited market power and access to market information, price fluctuations, diseases, loss of chickens during transportation, inadequate transportation facilities, hot climate, seasonal fluctuations in demand and supply and poor quality of birds (under-weight or poor health) (Bun and Brewster 2015, Siek et al. 2016, Sun 2018). High transportation costs and poor marketing infrastructure are the other major marketing constraints in the country (McNamara and Dahl 2016, ADB 2021). As indicated above, farmers located close to markets usually keep a greater number of chickens than farmers in rural areas. HPAI incidence creates higher uncertainty of poultry products consumption, as consumers cut their poultry products consumption and decrease production, particularly in the commercial production sector (Burgos et al. 2008). The above constraints could be mitigated by developing improved marketing systems that enhance smallholder producers' access to markets, such as transportation and marketing facilities and strengthening farmers' collective action (Sun 2018).

6 Nutritional contribution of smallholder poultry production

6.1 Nutritional status of households in southeast Asian countries

Nutrition is an essential factor for optimal growth and development in children. Dietary guidelines recommend a well-balanced diet that includes all major food groups to ensure sufficient intake of necessary macro and micronutrients (Bao et al. 2018). The nutritional status of households can be assessed using undernutrition (underweight, wasting and stunting), overnutrition (overweight) and micronutrient deficiency indicators for the most vulnerable segments of the population, such as children and reproductive-age women. Undernutrition remains a crucial challenge to regional health and development in Asian and African countries. These countries have among the most nutritionally deprived populations in the world. According to the FAO (2021), the prevalence of stunted children in southeast Asia was 24.7%, which was higher than regional (21.8%) and world (21.2%) averages in 2019. Stunting is a consequence of chronic nutritional deprivation that can commence during pregnancy due to maternal malnutrition and other in-utero adversities (Black et al. 2013). Undernutrition is associated with high child mortality and morbidity, poor motor and cognitive development, lower educational attainment, and economic productivity in adulthood (Sudfeld et al. 2015). Moreover, short maternal stature, a long-term consequence of stunting in girls, is further associated with fetal growth restriction leading to neonatal death and stunting in the next generation (Katz et al. 2013).

Anaemia is another important indicator of micronutrient deficiency in most developing and developed countries. The prevalence of anaemia in Asia has historically been higher than global averages. For instance, during 2016, the prevalence of anaemia among reproductive-age women was 36.6%, while the global average was 32.8% (FAO 2021). Maternal and child anaemia have multi-factorial causes involving complex interactions with nutrition and have serious consequences for maternal and child survival and health, healthy pregnancies, cognitive development and work productivity (Balarajan et al. 2011).

Studies showed that a large proportion of children in Southeast Asia did not meet their daily recommended intake of many nutrients, including calcium, iron, vitamins C and D (Chaparro et al. 2014). The leading causes of undernutrition in southeast Asia include inadequate dietary intake (quantity and quality), low birth weight, low maternal nutritional status, inadequate breastfeeding practices and complementary feeding practices, unhealthy environments and limited access to health care services (Chaparro et al. 2014). Poverty, food insecurity, high population density, lack of land ownership, gender inequality and poor economic and social status of women also contribute significantly to the undernutrition of children. Smallholder poultry production plays an important role in the fight against child undernutrition by addressing some of the challenges related to dietary intake, food security, poverty reduction, gender equality and women empowerment (Dolberg 2003, Alders and Pym 2009, Wong et al. 2017, Omer 2020).

6.2 Nutritional status of children and women in Cambodia

Similar to other southeast Asian countries, undernutrition is Cambodia's major health and development concern (NIS 2015a, Blaney et al. 2019). The 2014 Demographic and Health Survey report shows that 32% of Cambodian children under the age of five were stunted, with 9% of them being classified as severely stunted (NIS 2015a). These figures are higher than the sub-regional, regional and global averages. However, the proportion of stunted children declined from 49% in 2000 to 32.4% in 2014 (Table 2). Between 2000 and 2005, the proportion of children affected by wasting declined from 17.1 to 8.5% but increased to 11% in 2010 before dropping to 9.7% in 2014 (FAO 2021). Although the three-year average proportion of undernourished children decreased from 23.7% in 2000/02 to 14.5% in 2017/19, the 2017/19 figure was still higher than regional (8.3%) and global (8.8%) averages. This shows that undernutrition has remained the main nutritional challenge in the country.

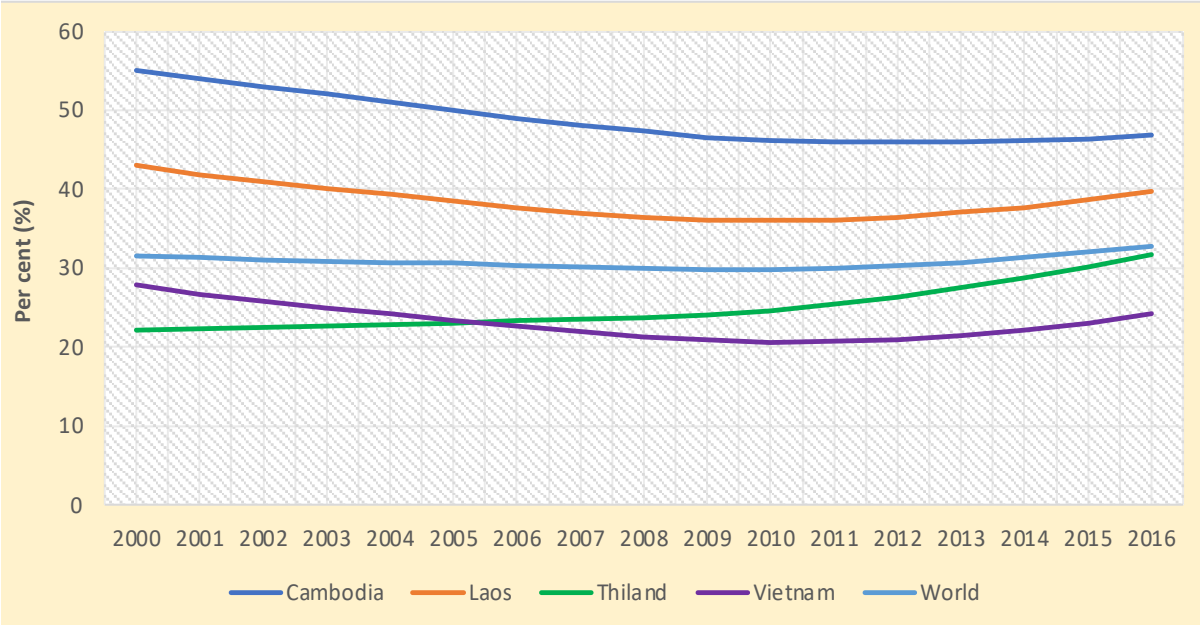
Table 2: Percentage of stunted children under five years of age in Cambodia.

	Stunting (%)			
Year	Cambodia	Southeast Asia	Asia	World
2000	49.0	38.5	37.8	32.4
2005	42.8	34.6	33.4	29.2
2010	39.8	30.8	28.8	26.0
2014	32.4	28.0	25.3	23.6

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

Anaemia has also been a major public health problem in Cambodia. More than half (56%) of children aged 6–59 months were anaemic, with 30% being mildly anaemic and 25% moderately anaemic (NIS 2015a). Children in rural areas were more likely to be anaemic than those in urban areas. The prevalence of anaemia among women of reproductive age (15–49 years) was also higher than the regional and global averages (Figure 7). In 2016, 46.8% of women of reproductive age were anaemic, and in the same year, the global and regional prevalence was 32.8 and 36.6%, respectively. Compared to neighbouring countries such as Laos, Thailand and Vietnam, the prevalence of anaemia in Cambodia has remained the highest in the last two decades.

Figure 7: Prevalence of anaemia among women of reproductive age in Cambodia.



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

6.3 Household diet diversity and poultry products consumption

Household diet diversity is one of the most reliable food security outcome indicators used in various research and development efforts. It reflects the extent to which a household has access to diverse foodstuffs and serves as a proxy for the nutrient adequacy of an individual's diet (FAO 2010). The role of animal source foods (ASFs) (e.g. meat, fish, milk, and eggs) in enhancing household diet diversity as suppliers of high-quality, readily digested protein and energy and readily absorbable and bioavailable micronutrients has been documented in various studies (Murphy and Allen 2003, Zhang et al. 2016, Adesogan et al. 2020). The inclusion of ASFs in the diet promotes growth, enhances cognitive function and physical activity and boosts the overall health of most vulnerable household members, particularly children and pregnant women (Jin and Iannotti 2014, Iannotti 2018, Shapiro et al. 2019). For instance, according to Adesogan et al. (2020), ASFs supply high-quality and nutrient-rich food for children aged 6–23 months. Thus, consumption of ASFs has been encouraged to improve the nutritional status of households in developing countries s (Neumann et al. 2014).

Since poultry production is a principal activity among rural and resource-poor households, poultry products play a crucial role in improving dietary diversity and the nutritional quality of these households. The main outputs from smallholder poultry production, e.g. meat and eggs, are sources of high-value nutrition for the most vulnerable members of both urban and rural households, such as pregnant women, children and the sick (Wong et al. 2017, Alders et al. 2018, Passarelli et al. 2020). Chicken meat is lean and high in protein and supplies significant amounts of micronutrients such as iron, zinc and vitamins (Marangoni et al. 2015). Similarly, eggs provide proteins and substantial amounts of several important vitamins and minerals such as vitamins A and B12, folate, thiamin, riboflavin, phosphorus and zinc (WHO 2017, Réhault-Godbert et al. 2019). Research findings show that an egg is an essential energy source and provides a significant proportion of an adult's daily nutrient requirements (Kovacs-Nolan et al. 2005, Réhault-Godbert et al. 2019). Of the daily nutritional requirements, it provides selenium (27%), vitamin B12 (25%), choline (23%), riboflavin (15%), protein (13%), phosphorus (11%), vitamin D (9%), folate (9%), vitamin A (8%), iron (6%) and a small amount of zinc (FAO 2015).

Research on the effect of poultry meat and egg intake on young children's health and nutritional status has also documented a significant positive effect of poultry product consumption on different nutritional and health outcomes in children (Kovacs-Nolan et al. 2005, Omer 2020, Passarelli et al. 2020). For example, an experiment in Ecuador documented significant improvements in nutritional outcomes and a reduction in stunting among children through feeding one cooked whole egg per day for six consecutive months (Tran et al. 2017).

Empirical studies show high food insecurity and low dietary diversity in Cambodia (McDonald et al. 2015, Som et al. 2018, FAO et al. 2020). According to the FAO et al. (2020), the prevalence of moderate/severe food insecurity in the country was 44.1% from 2017–19. In Cambodia, the concept of food security is primarily associated with rice production and consumption, while household diet diversity has received little attention (Keats et al. 2018). The low level of protein, micronutrients and vitamins consumption could be related to inadequate consumption of livestock products such as meat, milk and eggs. This could be due to the lower production and productivity of the livestock sector. There is a higher prevalence of food insecurity and undernutrition in rural areas in comparison to urban areas, which is associated with limited access to nutrient-dense food and inadequate knowledge and skills in household nutrition (McDonald et al. 2015, FAO et al. 2020).

Smallholder poultry production contributes significantly towards households' food security by providing meat and eggs and generating additional income to purchase other food items (Ashley et al. 2018). In Cambodia, poultry meat is the third most consumed animal meat, after pork and beef. For instance, from 2000–13, poultry meat's average per capita consumption was 2.01 kg/year, while the per capita consumption of pork and beef was 8.38 and 5.11 kg/year, respectively (FAO 2021). Findings from NIS show an upward trend in egg and meat consumption frequency in the last few years across all zones in Cambodia (Table 3). For example, the national average for frequency of egg consumption

increased from 1.3 days per week in 2014 to 2.4 days per week in 2019/20. Similarly, the household average for frequency of meat (including poultry) consumption increased from 2.2 days per week in 2014 to 3.3 days per week in 2019/20. Table 3 shows that average meat and egg consumption in rural areas was slightly lower than in urban areas. Household animal product consumption varies with household income, proximity to markets and prevailing market prices (Coad et al. 2019).

Table 3: Frequency of meat (poultry and others) and egg consumption in Cambodia.

	Meat and Poultry (Number/week)				Egg (Number/week)			
Year	Cambodia	Phnom Penh	Other urban	Other rural	Cambodia	Phnom Penh	Other urban	Other rural
2014	2.2	3.0	2.6	2.1	1.3	1.3	1.3	1.3
2015	2.9	3.7	3.1	2.7	1.7	1.5	1.8	1.7
2016	3.0	3.7	3.1	2.9	1.6	1.6	1.7	1.6
2017	3.0	3.5	3.1	2.9	1.8	2.1	1.9	1.7
2019/20	3.3	3.7	3.5	3.1	2.4	2.4	2.5	2.3

Sources: Compiled by authors using data from NIS (NIS 2015a, NIS 2018, NIS 2020b)

A comprehensive review of empirical studies in developing countries demonstrates the effectiveness of integrating poultry production and nutrition education interventions on household nutrition outcomes (Omer 2020). For instance, an integrated research project that promoted smallholder poultry production, home gardening and nutrition education in India reported increased egg intake (Murty et al. 2016). Similarly, an integrated study in Ghana reported the positive impact of improved poultry production and nutrition education on households' nutritional outcomes (Marquis et al. 2018). Different interventions explored the role of increased egg intake among infants and young children in Cambodia (Burgos et al. 2008, Reinbott et al. 2016). For instance, Reinbott et al. (2016) conducted a study that showed the role of improved chicken production and nutrition education on households' nutritional outcomes. The research included chicken production in both treatment and control groups and additional nutrition education for 2–3 months for the treatment groups. The nutrition education focused on promoting feeding infants and young children with eggs and other animal products and conducting cooking demonstration sessions. The results from this study showed an increase in egg consumption in the treatment group (33 to 46%) compared to the control groups (30 to 36%).

The above findings demonstrate the vital role of integrated poultry interventions in enhancing dietary diversity in rural and agricultural households. Interventions that focus only on nutrition education may not achieve the desired outcomes as households may not be able to buy poultry products due to low household income and/or lack of market access. Similarly, enhancing households' poultry production and productivity alone may not result in desired outcomes due to a lack of supporting changes in consumption behaviour and cooking skills as well as the preference for households to sell poultry products to generate income rather than using them for their own consumption. Therefore, integrating poultry production and nutrition education interventions is recommended for countries interested in mitigating malnutrition through poultry product consumption.

7 Economic contribution of smallholder poultry production

The role of poultry production in poverty reduction and economic development in developing countries is documented in various empirical studies (Mack et al. 2005, Alders and Pym 2009). Similarly, poultry production in Cambodia contributes to household livelihoods and the national economy since most of the households produce birds at very low costs (NIS 2015b). In addition to own consumption, most agricultural households use chicken and ducks to generate income (FAO 2009c, Ashley et al. 2018). For instance, a study conducted by the FAO (2009b) shows that about 83.5% of respondents rely on poultry for food and income generation.

In Cambodia, an estimated 82.1 and 11.7% of the total livestock meat produced in 2019/2020 came from chickens and ducks, respectively (NIS 2020b). During the same period, cattle and pig meat constituted only about 2.0 and 1.9% of total livestock meat, respectively. However, the average income generated from the sale of chickens and ducks in those 12 months accounted for 13.9 and 4.1% of the total revenue generated from livestock sales, respectively. The highest proportion of income was generated from the sale of cattle. Unlike the sale of live animals, the highest proportion of income was generated from selling other livestock products such as duck eggs (70.9%) and chicken eggs (5.6%). This shows the vital role of poultry production in household income generation.

In most rural areas of Cambodia, poultry production is the second major source of income after rice production, and it significantly contributes to job creation and poverty reduction (Sun 2018). Moreover, according to the FAO (2009c), in some cases, poultry is the only livestock owned by poor rural and urban households. For some producers, it is the main economic activity. The income generated from poultry production can be used to purchase goods for household use (food, clothing, and shelter); savings for emergencies, and settling school fees, medical expenses, and other household expenses (Heft-Neal et al. 2012). There is spatial variability in the economic contribution of poultry production among households that are associated with the level of production and diversity of households' livelihood activities.

Poultry production also contributes to the livelihoods of other value chain actors such as input suppliers, collectors and traders. Even though there is limited empirical evidence, available research shows that poultry production generates income for different actors. For instance, according to the FAO (2009a), the marketing of poultry products contributed an average of 67.6% of traders' household incomes. Similarly, according to Heft-Neal et al. (2009), poultry products contributed about 60.5% of aggregators' household incomes.

Poultry production also contributes to economic equity and women empowerment, as most of the income generated from poultry production is controlled and managed by women (Burgos et al. 2008, FAO 2009c, Heft-Neal et al. 2012). In Cambodia, the share of female-headed households engaged in livestock/poultry production is higher than that of female-headed households engaged in crop production. For example, while the share of female-headed households who owned agricultural land was 11.7%, the share of female-headed households engaged in livestock/poultry production was 42.9% (NIS 2020b). In Cambodia, women are traditionally responsible for poultry and pig production (ADB 2021). Given

the high proportion of poultry-raising households in the country, improving the production and productivity of poultry would directly enhance the livelihood of women. Moreover, compared to other livestock species, poultry production has multiple comparative economic and non-economic advantages that directly or indirectly affect the livelihood of women. This may include flexibility of the production system; low input requirement; the potential to serve as the first rung in the livestock production ladder, high-quality protein; contribution to income generation and gender sensitivity; robustness and agility and lower environmental impacts (Copland and Alders 2005).

8 Overview of agricultural policy and research in Cambodia

The agricultural sector is a priority in the development policies and strategies of Cambodia. This is reflected in the country's 'Rectangular Strategies' and 'National Strategic Development Plan 2014–18' (RGC 2013, RGC 2014, RGC 2018). Furthermore, plans to enhance production and productivity of the sector through improved technologies, diversification and commercialization, land reforms, sustainable management of natural resources and other strategies have been clearly stated in various policy documents (MAFF 2015b). The country has developed a long-term strategy to modernize the agricultural sector from an extensive to the intensive production system (SNEC 2019). The country's agricultural policy has three strategic objectives: boosting economic opportunities, enhancing food security and promoting environmental sustainability.

The Royal Government of Cambodia (RGC) has adopted different strategies to create different agricultural transformation policies that include productivity enhancement, diversification, and agricultural commercialization. These strategies are to be implemented by supporting nationally recognized agricultural research and extension systems (MAFF 2015a). Since 1957, the agricultural extension system in Cambodia has evolved through various stages. It aims to transfer knowledge, information and technology to farmers and farming communities and further link them to markets (MAFF 2015a, Ke and Babu 2018). Unlike previous strategies, the recent agricultural extension approach adopts a demand-driven strategy that includes technology development, packaging, and learning. Most extension activities are funded by the General Directorate of Agriculture, Cambodia Agriculture and Rural Development Institute (CARDI) and other national and international research institutes.

Despite the low productivity and other multifaceted challenges facing the Cambodian agricultural sector, investment in agricultural research is considered very low. Indeed, funding allocated to agricultural research is generally low compared to other developing countries. For instance, spending on agricultural research was about 0.22% of agricultural GDP in 2017 (Stads et al. 2020). Nevertheless, in addition to government funding, some research and extension activities have been supported by international donors such as ACIAR, CARDI, United States Agency for International Development (USAID), International Fund for Agricultural Development (IFAD), European Union, Asian Development Bank, World Bank, McKnight Foundation, Nippon Foundation and other international and regional organizations (Stads et al. 2020). Among the above donors, ACIAR has been reported as the largest and most consistent funder of a range of agricultural research and extension activities related to crops, livestock, soil, marketing, postharvest and aquaculture.

Traditionally, agricultural research and extension activities in Cambodia have mainly focused on crop production, especially rice. The attention given to livestock research is significantly lower than that given to crop research. For example, there were 67.8% crop researchers versus 10.7% livestock researchers in 2017 (ASTI 2018). Within the crop researchers' category, 46.5% were rice researchers and the remainder researched on maize, cassava, rubber and vegetables. Due to the low number of livestock researchers, this sector faces persistent challenges that make it less

competitive than other countries in the region (SNEC 2019). Major challenges include the high cost of production, limited extension support, lower technology adoption, lack of quality control on animal breeds (chicken and pig) and feeding materials and unfair contract farming practices between farmers and commercial companies (SNEC 2019).

In Cambodia, livestock production is characterized by lower productivity of existing breeds, high cost of animal feed and weak animal health management systems (Seng 2017). As a result, research on animal production, genetics, nutrition, health and breeding has been prioritized in the last few years. The main research objective is to improve the production and productivity of animals through breed improvement and better nutrition (MAFF 2015b). Given the low productivity of the sector and the country's dependence on imported animal products, previous research and extension efforts were designed to achieve self-sufficiency and diversify agricultural production in the country.

Comprehensive research and development efforts to improve poultry production and productivity are essential if the increasing demand for poultry products is to be met in Cambodia. These research and development efforts should focus on improving the productivity of existing breeds; enhancing the sector's efficiency through multi-environment performance evaluation; dissemination of locally adapted, farmer-preferred and improved chicken genotypes; integration of disease prevention and control systems and improvement of input delivery and output marketing systems. As indicated by the IMF (2006), improving the productivity of the poultry sector by introducing high-performance genetics and employing better management options would significantly reduce poverty among rural households. Moreover, potential interventions that aim to improve the production and productivity of chickens should consider the formation of cooperatives, public-private partnerships, developing products certifications and enhancing access to information (Sun 2018).

9 Conclusion and research implications

The purpose of this review was to understand the existing knowledge base on smallholder poultry production and marketing systems in Cambodia and to identify research and development gaps and opportunities. The review showed that the traditional/smallholder poultry production system produces the highest proportion of poultry meat and eggs and supports the livelihood of most rural and agricultural households in the country. This production system positively contributes to food security, income generation, poverty reduction and women empowerment in the country. However, the production and productivity of the sector are exceptionally low due to various production and marketing constraints. The review revealed that the country's average consumption level of poultry meat and eggs remains lower than regional and global averages. Lower consumption of poultry products could be associated with low production and productivity, limited household income, inadequate nutrition knowledge, inadequate access to markets and other institutional and sociocultural factors. Comprehensive research and development efforts to improve poultry production and productivity in the smallholder systems are essential if the increasing demand for poultry products is to be met. Research interventions should focus on improving the traditional husbandry practices and the initiation of genetic improvement programs. Genetic improvement efforts can focus on either improving the genetics of existing breeds or the introduction of locally adapted and farmer-preferred improved commercial breeds. On the other hand, development efforts should include integrating sustainable chicks and inputs delivery models, developing innovative business production and marketing models and providing households with knowledge on integrated poultry production and consumption practices.

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