



FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

FEED THE FUTURE INNOVATION LAB FOR LIVESTOCK SYSTEMS

ETHIOPIA'S LIVESTOCK SYSTEMS

Overview and Areas of Inquiry



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Sustainably intensifying smallholder livestock systems to improve human nutrition, health, and incomes

About Us

The U.S. Agency for International Development (USAID) awarded the University of Florida (UF) Institute of Food and Agricultural Sciences (IFAS) funds to manage the Feed the Future Innovation Lab for Livestock Systems. This ten-year initiative (Phase I 2015-2020, Phase II 2020-2025) supports USAID's agricultural research and capacity building work under Feed the Future, the U.S. Government's global hunger and food security initiative. The International Livestock Research Institute (ILRI) is the UF/IFAS main implementing partner. The five target countries for this project are: Burkina Faso and Niger in West Africa; Ethiopia and Rwanda in East Africa; and Nepal in Asia.

Disclaimer

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Acronyms

ASF	Animal-source Foods
AOI	Areas of Inquiry
ATEVT	Agricultural Technical Educational and Vocational Training
BTB	Bovine Tuberculosis
CBPP	Contagious Bovine Pleuropneumonia
CCPP	Contagious Caprine Pleuropneumonia
CSD	Camel Sudden Death
CSA	Central Statistics Agency of Ethiopia
DALY	Disability Adjusted Life Year
DOCs	Day-Old-Chicks
ECF	East Coast Fever
EED	Environmental Enteric Dysfunction
EIAR	Ethiopian Institute of Agricultural Research
ELISA	Enzyme-Linked Immunosorbent Assay
EMDIDI	Ethiopian Meat and Dairy Industry Development Institute
EPPPA	Ethiopian Poultry Producers and Processors Association
ESAP	Ethiopian Society of Animal Production
ETB	Ethiopian Birr
FBD	Foodborne Disease
FMD	Foot and Mouth Disease
FERG	Foodborne Disease Burden Epidemiology Reference Group
GDP	Gross Domestic Product
HACCP	Hazard Analysis and Critical Control Points
HARC	Holetta Agricultural Research Centre
HIV	Human Immunodeficiency Virus
HPAI	Highly Pathogenic Avian Influenza Virus
IBD	Infectious Bursal Disease
ILRI	International Livestock Research Institute
LMIS	Livestock Market Information System
LSD	Lumpy Skin Disease
LSIL	Livestock Systems Innovation Lab
MERS-CoV	Middle East Respiratory Syndrome Corona Virus
MeTRS	Meta-total RNA Sequencing
NOHSC	National One Health Steering Committee
NCD	Newcastle Disease
PCR	Polymerase Chain Reaction
PPR	Peste des Petits Ruminants
RVF	Rift Valley Fever
SNNPR	Southern Nations Nationalities and Peoples' Region
TB	Tuberculosis
TEVT	Technical, Educational and Vocational Training
TLU	Tropical Livestock Units
UHT	Ultra-High-Temperature
USAID	United States Agency for International Development
ZOI	Zone of Influence

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Introduction

Ethiopia is a target country of the United States Feed the Future initiative as well as a focus country for Resilience, Nutrition and Water (USAID 2021; USAID, 2018; USAID, 2018b; United States, 2017). The list of woredas under USAID's zones of influence (ZOI) for Ethiopia is located in Annex Table 3. Ethiopia is categorized as a low-income country by the World Bank and ranks 173rd out of 189 countries on the Human Development Index scale (World Bank, 2021, UNDP, 2021). Nearly 79% of the population lives in rural areas, and 30.7% lives below US\$1.90 purchasing power parity per day (World Bank, 2021b). Ethiopia's population growth rate is 2.6%, and 40.3% of the population is between 0 and 14 years of age (World Bank, 2021b). The prevalence of stunting among children under five is 36.8% (EPHI & ICF, 2019).

Animal Source Food Production and Disease Management (AOI #1)

Livestock Numbers

Ethiopia has the largest livestock population in Africa, with 65 million cattle, 40 million sheep, 51 million goats, 8 million camels and 49 million chickens in 2020 (Central Statistics Agency, CSA, 2020a). Between 2000 and 2016, the average stock of livestock, measured in tropical livestock units (TLU) per 100 people, stood at 51 TLU, which is more than double the continental median of 23 TLU. The gross production value average growth rate during the same period was 4.5% — also twice the continental median of 2.2% (FAO, 2019). The national herd supports, at least in part, the livelihoods of more than 11.3 million rural households, including 27– 35% of the highland livestock keepers, and a large proportion of the lowland herders, who live below the Government of Ethiopia established poverty line (Shapiro et al., 2017).

Livestock is a major source of animal protein, power for crop cultivation, means of transportation, export commodities, manure for farmland and household energy, security in times of crop failure, and means of wealth accumulation. The sector contributed up to 40% of agricultural Gross Domestic Product (GDP), nearly 20% of total GDP, and 20% of national foreign exchange earnings in 2017 (World Bank, 2017). Table 1 shows the main livestock species by Region.

Table 1. Estimated Numbers of Livestock in Ethiopia by Region

Region	Cattle	Sheep	Goats	Poultry
Tigray	4,908,964	2,097,619	4,838,969	6,317,518
Afar	1,952,394	4,040,176	8,531,082	92,941
Amhara	16,318,446	10,386,223	6,883,316	16,827,119
Oromia	25,031,068	9,260,493	7,526,644	16,668,657
Somale	3,646,940	9,188,394	17,001,672	354,264
Benshangul-Gumuz	626,537	72,284	404,015	884,660
SNNP	12,404,963	4,735,604	4,819,573	7,347,205
Gambela region	327,801	43,903	134,206	229,151
Harari	69,615	4,236	103,567	104,585
Dire Dawa Astedader	67,364	65,462	258,629	129,575
	65,354,092	39,894,394	50,243,044	48,955,675

Source: CSA (2020a)

The Ethiopian livestock population is almost entirely composed of indigenous animals. Recent estimates showed that 97.8%, 1.9%, and 0.3% of cattle are indigenous, hybrid, and exotic breeds, respectively. The estimates for sheep are 99.6% and 0.3% for local breeds and hybrids, respectively; for poultry 81.7%, 10.9%, and 7.4% are indigenous, hybrids and exotic, respectively. Nearly all goats (99.9%) are indigenous breeds (CSA, 2020a).

In Ethiopia, the term “poultry” is almost synonymous with chicken as other poultry species such as guinea fowl, geese, turkeys, and ducks are not common in the country. Chicken production offers considerable opportunities for generating employment, improving family nutrition, empowering women (especially in rural areas) and ultimately ensuring household food security. Figure 1 shows a marked increase in the poultry population from 2005 to 2016.

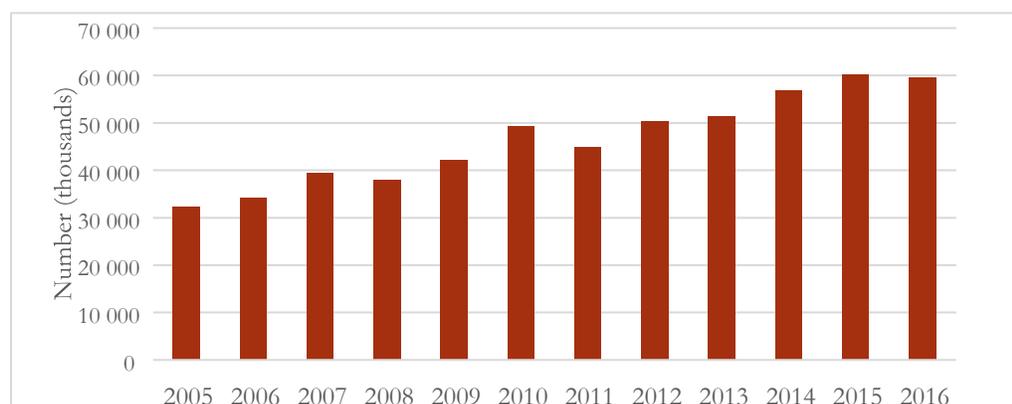


Figure 1. National poultry population, 2005–2016 (Source: FAO, 2019)

Management Practices

The livestock production system is predominantly extensive, with indigenous breeds and low-input/low-output husbandry practices. The productivity of this sector is constrained by several factors, including poor genetics, low reproductive performance, poor quality and varying seasonal availability of feed, high disease incidence and parasite challenges, and low accessibility to services and inputs. Milk production averages only 1.35 liters per day per cow and 5.16 liters per day per camel. The use of animals depends on the production system and the ethnic group(s); for instance, sheep are kept primarily for cash income in the mixed farming system, such as in North Shoa of Amhara region, but milk production is rationale for keeping sheep in the Afar region (see Table 2) (Getachew, 2010). Small ruminants are a major source of cash income for rural women (Biffa et al., 2006). Extensive scavenging poultry production is often the domain of poor women because it requires little initial investment and does not usually conflict with women’s other household duties. There are three predominant management systems in the country: intensive management, mixed crop-livestock, and pastoral/agro-pastoral (extensive).

Table 2. Livestock species, purposes of livestock keeping, and major constraints in the mixed crop-livestock system, Ethiopia

Livestock Species	Purposes of Keeping Livestock	Major Constraints for All Types of Livestock	References
Cattle	Draft power, manure, meat, milk, cash	1. Shortage of feed, both in quantity and quality 2. Insufficient and inefficient artificial insemination (AI) service (only for cattle) 3. Diseases and parasites	Abate (2012)
Sheep	Meat, manure, wool/fiber, cash		Duguma et al. (2012)
Goats	Meat, manure, cash		Duessa et al. (2014)
Poultry	Meat, eggs, cash		Geleti et al. (2014b)
			Feyissa et al. (2014)

Livestock Species	Purposes of Keeping Livestock	Major Constraints for All Types of Livestock	References
Equine	Draft power, transportation	4. Lack of veterinary clinics or shortage of facilities and drugs 5. Unsatisfactory credit service 6. Lack of awareness about productivity improving technologies 7. Lack of motivation to increase productivity due to other priorities.	

Intensive Management

The intensive management system is practiced on market-oriented dairy and poultry farms in urban and peri-urban areas, where exotic breeds or crossbred animals are mainly kept for their high performance (Tegegne et al., 2013). In this system, milk production is market oriented and is predominantly from high yielding improved exotic breeds or crossbreeds with local cows. Intensive management involves relatively high inputs and technology. The fluid milk produced is channeled to urban dwellers, restaurants and cafes, or milk processing plants. The main feeds available for urban dairying are crop residues, hay, and industrial by-products and some farms devote land to produce improved forage. In most cases, free grazing is limited due to lack of land, and thus stall feeding is common. Shortages of feed and high feed prices, disease incidence, lack of land/space, shortage of genetically improved heifers for expansion, limited market outlets and seasonal fluctuation in demand for milk and meat are factors that limit the development of urban dairying in Ethiopia (Tegegne et al., 2013; Welearegay et al., 2012).

Mixed—Crop Livestock

The mixed crop-livestock farming system is the dominant livestock production system in the Ethiopian highlands. In this system, crops and livestock play interdependent roles, with livestock providing draught power and manure for crop agriculture while crop residues provide feed for the livestock (Yisehak, 2008). In the mixed farming system, livestock follow crops as the means of livelihood (Tegegne et al., 2013). For instance, in the Sinana district (Bale Zone) of southeastern Ethiopia (Abate, 2012) and the Diga district of western Ethiopia (Duressa et al., 2014), livestock contribute respectively 25-41% and 33-36% of household livelihoods; and in Dandi, central Ethiopia, only 2.6% of the respondents to a survey considered livestock as their primary means of making a living (Duguma et al., 2012). Cattle are the most important livestock species in this system because they are used for ploughing, threshing crops, and providing manure. Sheep, goats, and poultry are also important sources of income, meat, draft power, and manure. Some farmers keep one or more improved cows for milk production (Duressa et al., 2014; Abate, 2012).

Due to the emphasis on crop cultivation, the number of livestock kept per household in mixed farming areas is low. In Central Ethiopia's Dandi district, for example, the following average numbers of livestock are kept per household: cattle (4.5), sheep (1.1), goats (0.5), equines (0.8), and poultry (3.0) (Duguma et al., 2012). Different livestock species are often kept in separate places, such as an open barn for cattle and equines and a small barn for small ruminants and young calves; sharing of the living space in the house at night with livestock is not uncommon (Duressa et al., 2014; Abate, 2012, Duguma et al.; 2012.). The mean number of household members in the mixed crop-livestock farming system is about six people (Tegegne et al., 2013; Duguma et al., 2012). Children are involved in herding and watering of livestock; women are responsible for collecting water, milking, milk processing, selling milk products, cleaning the barn or animal shed and men are mainly responsible for feeding the livestock with hay and crop residues. Decision making about breeding and marketing of animals, feeding oxen, and taking animals to the veterinary clinic is usually the responsibility of men, whereas, looking after calves and sick animals and feeding cows are predominant roles for women (Balehey et al., 2018; Mulugeta and Amsalu 2014).

Livestock production in the mixed farming system is limited by several factors: declining availability of grazing lands due to human population growth and increasing crop cultivation areas (Abate, 2012); poor production and reproductive performance of animals (Duguma et al., 2012); and lack of or inadequate access to technologies (Duressa et al., 2014). The average farmland per household is 1.4 ha in Lemo district (Hadiya zone), one of the densely populated areas in the Southern Nations Nationalities and Peoples' Region (SNNPR) and 4.5 ha in Bale, a less densely populated area in Oromia (Abate, 2012). Land holdings per household are relatively smaller in northern and central highlands. A summary of livestock species in the mixed crop-livestock system, purposes of keeping livestock, and major constraints are depicted in Table 2.

Pastoral

Pastoral and agro-pastoral livestock production are the second most dominant systems in Ethiopia and they are mainly in southern and eastern parts of the country in Afar, Somali, Southern Oromia (Borana), Kereyou in East Shoa and South Omo in SNNPR. There is no crop production in the pastoral system, but agro-pastoralism is characterized by dominance of livestock husbandry and limited crop production (Tegegne et al., 2013). Transhumant systems that involve the seasonal movement of animals from mixed crop livestock systems to highland and lowland rangelands, such as in western Tigray and Amhara regions, are also categorized under agro-pastoral system (Nyssen et al., 2009; Tegegne et al., 2009). These production systems can be categorized as extensive livestock management systems with low-input and low-output. In southern pastoral and agro-pastoral areas of Ethiopia (Borana zone of Oromia and Liban zone of Somali), cattle are the most numerous species, followed by goats, camels, and sheep, with means of 21.1, 13.8, 9.8, and 9.5 animals per household, respectively. In contrast, in Afar and Somali pastoral areas, camel followed by goats and sheep are the most important animals. Livestock is a means of livelihood for 90% and 93% of households in Borana and Liban, followed by crop production (60% and 36.7%), and trade (10% and 3.3% respectively). Sales of animals, animal product and crops contributed 75%, 60%, 5% of household income in Borana and 80%, 37%, 10% of household income in Liban, respectively (Tolera and Abebe, 2007).

Poultry Production

Poultry is one of the most important agricultural subsectors for rural communities in Ethiopia. The poultry production systems of Ethiopia are classified into the industrial and integrated/medium- and large-scale intensive systems and the different categories of family poultry production systems (i.e., the small-scale intensive, semi-intensive, extensive scavenging and small-extensive scavenging systems (FAO, 2019b). Producers keeping over 1,000 broilers, or 500 layers are considered the medium- and largescale intensive systems. Within such systems, there are large variations among producers in terms of technology use, management level and scale of operation. Medium- and large-scale intensive poultry producers are mainly located in and around cities and major towns such as Addis Ababa, Debre Zeit and Adama. Broiler production is concentrated in Adama, Modjo and Debre Zeit; pullet rearing is heavily concentrated in Debre Zeit; while egg production is mainly in Addis Ababa (FAO, 2019b).

The total number of small-scale intensive poultry producers and their specific contribution to the national poultry production is not known. However, they provide the largest share of poultry eggs and meat to the growing urban population (Boere et al., 2015). Their distribution is similar to that of medium- and large-scale intensive poultry producers. The semi-intensive family poultry producers, instead, are also common in rural areas connected to urban markets.

Family poultry systems are mostly found in the highlands (both in the mixed rainfall sufficient and mixed rainfall deficient typology zones) and more rarely in agro-pastoral areas. Pastoral communities do not keep chickens at all. In rural areas, family poultry production systems generate tremendous opportunities to improve food security and nutrition and empower women. Family poultry production is a suitable enterprise for women and poor households due to the small quantity of land needed and low start-up costs. Family poultry production can empower rural women, despite their often-poorer access to land and inputs as well as their heavy work burden within rural households.

In this overview document, family poultry production systems are classified into four groups based on market access, production objectives, level of specialization/technology use, flock size, etc. (FAO, 2014). The characteristics of such systems in Ethiopia are described below. The extensive scavenging and small-extensive scavenging systems are the dominant forms of poultry production in Ethiopia (CSA, 2020a).

Large scale commercial farms

The role of the commercial sector is increasing (16.52% meat production and 25% egg production) and overtaking the share of the traditional backyard poultry farming system in terms of production volume (ENTAG, 2020). The commercial poultry sector has about 71,000 broiler breeder stock, 87,300-layer breeder stock and 141,700 dual-purpose parent stock (ENTAG, 2020). All the large-scale and some of the medium-scale poultry farms depend on their own parent stock to ensure sustainable production of day-old-chicks (DOCs). All parent stocks are imported and popular parent stock breeds for broilers include Cobb-500, Hubbard, and Rose 308. Likewise, common layer and dual-purpose breeders in Ethiopia include Bovans Brown, ISA, Lohmann, TETRA-SL and Sasso. Sasso, which is a dual-purpose breed, dominates the Public-Private Partnerships business model, which targets mainly the backyard production system. No company produces grandparent stock. Debre Zeit Agricultural Research Center (DZARC) has a pure line breed called Koekoek (about 3,800), which avoids the requirement for frequent imports of parent stock.

Poultry meat production is conservatively estimated to be 7,750 tons per year, considering the available 71,000 parent stock (broiler breeders; ENTAG (2020). Broiler production capacity of commercial farms in Ethiopia is shown in Annex Table 1. Based on data collected by ENTAG (2020), annual egg production is estimated at 1.83 billion eggs or about 73,357 tons. The population of indigenous layers has declined in the past 10 years due to expansion of the commercial sector. Egg production capacity of major poultry farms is shown in Annex Table 2.

Small-Scale Intensive

The small-scale intensive system involves use of specialized, commercial DOCs or pullets (200–1,000 broilers, 100–500 layers), commercial balanced rations, and good quality poultry houses. Producers in this system have full access to veterinary services and the mortality rates are low to medium (<20%). The small-scale intensive system is rapidly growing in the urban and peri-urban areas of the country. They are mostly run as family businesses and considered as important sources of income for many families. Small-scale intensive poultry production currently plays a significant role in the employment of youth. Producers obtain DOCs from the medium- and large-scale intensive poultry farms and hatcheries. They purchase compound feeds from large-scale intensive farms and feed mills, such as Alema Koudijs Feeds, but their supply is inadequate and intermittent. Most of the feed used by these producers comes from smaller feed mills, which include those preparing small quantities of poultry feeds at the household level and smaller feed mills processing feeds for poultry, sheep, goats, and dairy cattle.

Semi-Intensive

The semi-intensive system is characterized by flocks ranging from 50 to 200 birds, using commercial, crossbred, or indigenous breeds reared under scavenging management conditions with regular supplementation. Unlike in scavenging systems, birds are provided with housing and improved health care, resulting in low to medium mortality rates (<20%).

Extensive/Scavenging

The extensive scavenging system shares almost all the attributes described below for small extensive systems. However, it is based on a larger flock size (ranging from 5 to 50 birds) comprised of indigenous and/or crossbred chickens, and it is practiced by households with access to rural markets. Producers in this system do not have regular access to exotic chickens and usually raise their own replacement stock. Food security and income generation are the primary reasons for keeping chickens. They use broody hens to hatch

replacement stock. The small-extensive scavenging system is practiced by households located in remote villages with little or no access to markets, with the main purpose of chicken rearing being for household consumption. It is based on a flock size of 1–5 indigenous chickens kept under scavenging conditions. Birds have no or little supplementary feeds and no housing. Chicks are produced through natural incubation. This system is also characterized by high chicken mortality (often >70%) due to lack of proper health care and veterinary services. In extensive scavenging systems, poultry keeping is mainly an activity undertaken by women often as a source of supplementary income. Poultry can contribute to as much as 20–25% of the household income, much of which is controlled by women. A study by Gebremedhin et al. (2016) found that decisions on the income generated from scavenging poultry were made by women in 30% of the cases and by both women and men in about 54% of the cases. Poultry income is often used to cover school expenses, indicating that targeting rural women in family poultry development schemes does not only mean empowering women but also contributing to the education of their children.

Livestock Products

The estimate of total cow milk production for the rural sedentary areas of the country in 2019/2020 was about 3.89 billion liters (CSA, 2020a). The estimate of camel milk for pastoral areas of the country was about 1.82 billion liters. The estimate for total number of eggs produced was 317 million.

According to CSA (2020b), of the total annual milk production, 50% was used for household consumption, 10% was sold, 0.56% was used for wages in kind, and the rest (39%) was used for other purposes (e.g., to produce butter, cheese, yogurt, etc.). With respect to the utilization of butter, 55% of the produce was used for household consumption although a considerable portion (39%) was sold. Most of the total cheese produced was used for household consumption (77%), 17% was sold, and the rest (6%) was used for wages in kind and other purposes (Table 3).

Table 3. National livestock product utilization in 2019/2020

Type of Product	Household Consumption	Sale	Wages in Kind	Other
Milk	50.1%	10.0%	0.6%	39.4%
Butter	54.9%	38.6%	0.5%	6.0%
Cheese	77.2%	17.2%	0.5%	5.1%
Beef	56.9%	29.4%	1.9%	11.8%
Mutton/Goat Meat	88.9%	3.9%	0.4%	6.8%
Eggs	31.4%	46.8%	0.3%	21.5%
Skim milk	60.9%	2.8%	0.7%	35.5%
Camel Meat	46.5%	16.3%	1.9%	35.4%

Source: CSA (2020b)

The national level production and consumption of meat is indicated in Table 3. Livestock is a key source of industrial raw materials (milk, meat, hides and skin) and high value protein to potential consumers in Ethiopia (FAO, 2015; USAID, 2010). Due to low productivity, the average live weight of cattle is estimated at 250 kg; with 14% offtake rates and 110 kg carcass weight at 44% dressing (MOA, 2012; USAID, 2010). The offtake rates for sheep were 40% with 10kg of average carcass weight per sheep, whereas the offtake rate for goats was 27% with average carcass weight of 8kg/goat. (MOA, 2012; ESGPIP, 2011). The per capita consumption of meat in the country is very low (8.5kg) and is lower than the average per capita consumption in Africa.

Livestock Feed Resources

Green pasture (55.2%) and crop residues (30.8%) are the main feed types available in the country (CSA, 2020a). The available feed resources in the mixed crop-livestock production areas are natural pastures, crop residues, and to a lesser extent, improved forage, concentrates, and nonconventional feeds. Natural pasture is the primary feed source for livestock and is abundant during the rainy season. In some areas, it is harvested during wet seasons and conserved as hay for dry seasons (Duressa et al., 2014; Feyissa et al., 2014; Geleti et al., 2014b; Abate, 2012;). Crop residues are the second most abundant feed source and include straw or stover of teff (*Eragrostis tef*), barley, wheat, sorghum, and maize (Duressa et al., 2014; Tegegne et al., 2013; Duguma et al., 2012), and legume residues such as fava bean and field pea (Abate, 2012). Animals are fed on crop stubble during harvesting seasons. In some places, improved forage is cultivated and fed to dairy cows to increase milk production, but this practice is not widespread (Abate, 2012). Nonconventional feeds, such as weeds and brewers grains, a by-product of local *tella* (beer) production, are also fed to livestock (Feyissa et al., 2014). Agro-industrial by-products such wheat bran, oil cake, and molasses are available only to farmers close to urban areas, and they are unaffordable to most of them for frequent purchase (Geleti et al., 2014b; Yami, 2012). Available feed types and major constraints in three mixed crop-livestock production areas are presented in Table 4. The main feed types available for urban dairies are crop residue, hay, and agro-industrial by-products (Tegegne et al., 2013).

Table 4. Available feed types and major constraints in three mixed crop-livestock production areas, Ethiopia

Districts	Major Feed	Major Constraints	References
Sinana district (Bale), Oromia region, southeastern Ethiopia	<ol style="list-style-type: none"> 1. Crop residues (cereal straws of wheat, barley, and emmer wheat, and legume residues of fava bean and field pea) 2. Natural pasture 3. Cultivated fodder crops (maize and fodder oats) 4. Stubble grazing or aftermath 5. Weeds during rainy season 6. Linseed cake and wheat brans 	<ol style="list-style-type: none"> 1. Lack of knowledge of crop residue management, improvement and feeding 2. Lack forage seed and poor Extension services 3. Grazing land scarcity and low nutritional value of available feeds specially during the dry season 4. High price of concentrates 5. Cash shortage 6. Inadequate clean water 	Abate (2012)
Dandi district, Oromia region, central Ethiopia	<ol style="list-style-type: none"> 1. Natural pasture 2. Crop residues (straw of teff, wheat; maize stover) 3. Conserved hay 4. Stubble grazing or aftermath 5. Non-conventional feeds (brewers grains) 	<ol style="list-style-type: none"> 1. Land scarcity and lack of awareness about how to grow improved forage crops 2. Wet season feed shortage caused by water logging of grazing pasture and intensive cropping 3. Unaffordable price of concentrates 	Duguma et al. (2012)
Lemo district (Hadiya), SNNPR, southern Ethiopia	<ol style="list-style-type: none"> 1. Natural pasture 2. Crop residues (<i>Ensete</i> by-product; straw from wheat, barley, teff) 3. Roadside grazing and improved collected fodder 4. Concentrates (wheat bran and oil extract cake) 	<ol style="list-style-type: none"> 1. Shortage of land 2. Cash shortage and volatile price of concentrates 3. Transportation of concentrates 	Geleti et al. (2014b)

Free grazing is the most common feeding system in mixed crop-livestock farming areas, while stall-feeding is dominant in urban dairying. Animals graze on pasture along roads and rivers, and around homesteads in mixed farming areas (Abate, 2012, Duressa et al., 2014; Feyissa et al., 2014; Tegegne et al., 2013), and animals range free in the lowlands. Stall feeding is common in some places in the mixed farming system, and crop residues, forage, and weeds are given to the animals (Duguma et al., 2012; Geleti et al., 2014b). In some

places, like the Mieso district of Oromia, animals are tethered during crop cultivation but freely graze after harvesting season (Hussen et al., 2008). Some farmers (involved in selling milk mix crop residues with oil cake and wheat bran to increase palatability and nutritional value, and some provide improved forage and hay to dairy cows and oxen (Abate, 2012; Duguma et al., 2012). Seasonal purchase of concentrates for fattening animals and dairy cows is also common in some places (Feyissa et al., 2014). Salt supplementation is very common, but urea supplementation to increase the intake and nutritional value of crop residues is rare (Duressa et al., 2014).

The feeding system in pastoral areas is grazing. Milking cows, calves, and sick animals are kept around the homesteads, while other animals freely graze in rangelands far from home (Tolera & Abebe, 2007). The main feed resources available in pastoral and agro-pastoral areas, such as Borana Liban zones of Oromia, Somali and Afar, are natural pastures—herbaceous vegetation composed mainly of grasses and forbs, and browses such as shrubs, tree leaves, and pods—and Acacia species for browsing. However, the availability and quality of the pasture markedly fluctuates based on the variability and distribution of annual rainfall. Adequate feed is available during the rainy season, but pastures are depleted during dry seasons when pastoralists have to feed leaves and branches of trees to their animals. Pastoralists also migrate with their animals to areas of relative fodder and water abundance. Haymaking during feed surplus season is not common, but some rangeland areas are often fenced and reserved for dry seasons. The major constraints limiting feed availability in such areas are shortage of rain and frequently recurring drought, rangeland encroachment by undesirable plant species such as *Acacia drepanolobium* in Borana and *Prosopis juliflora* in Afar, expansion of cropping, land conversion to cultivation and private enclosures, and tribal conflicts (Tolera & Abebe, 2007). In addition, climate change has forced the pastoralists to shift the species of livestock from grazers (cattle and sheep) to browsers (camels and goats) (Amsalu et al., 2013).

In recent years, the prices of animal feeds are alarmingly increasing (Seyoum et al., 2018). The price trends of some feed ingredients compound feed are indicated in Figure 2 and Figure 3, respectively. This escalation in the prices of animal feeds is believed to be one of the major causes for a rapid increase in the price of animal source foods in the country. Consequently, animal source foods are becoming unaffordable to poor households; and this makes the fight against malnutrition and stunting much more difficult. Concerted effort should be made by policy makers, governmental and non-governmental bodies to improve feed availability at affordable price since improving feed availability is a prerequisite to improve supply of animal source foods and then improve household nutrition, income, and the livelihood of the poor households in Ethiopia.

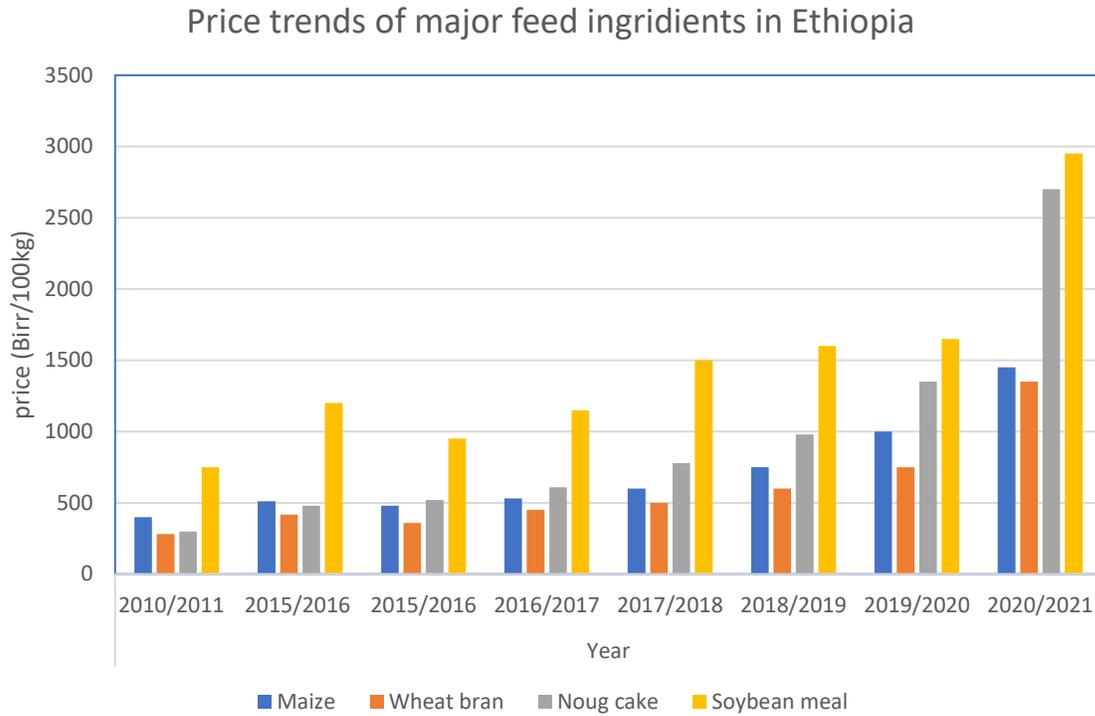


Figure 2. Price trend of major feed ingredients in Ethiopia

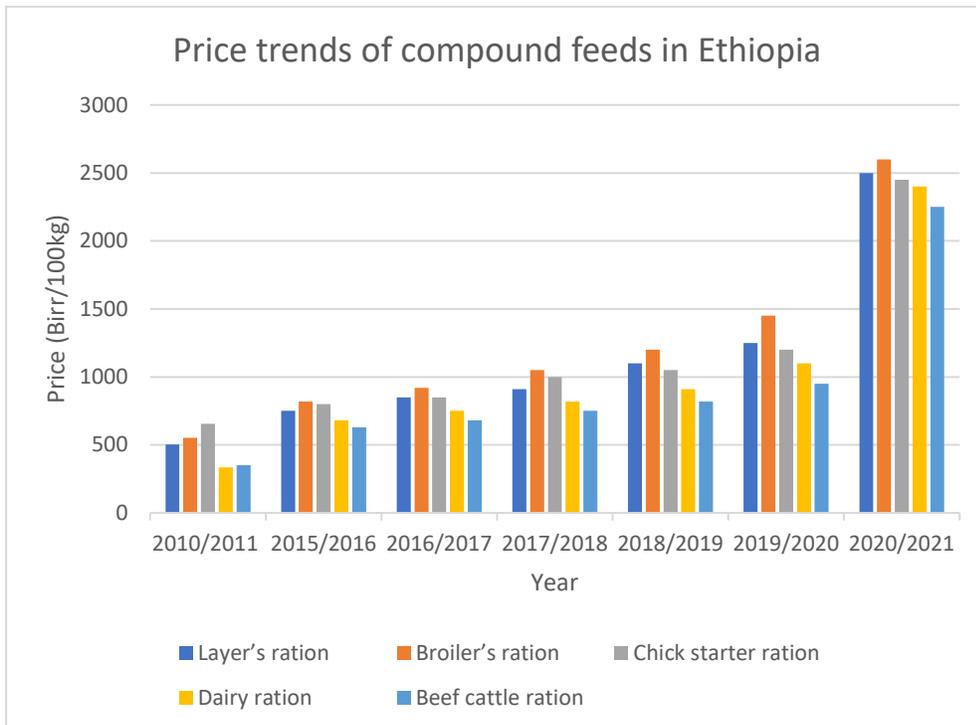


Figure 3. Price trends of major compound feeds in Ethiopia

Note: The figures were constructed using partial information from previous studies by Seyoum et al. (2018) and by using raw data obtained from Ethiopian Feed Association.

Use of Manure and Livestock Waste

Use and disposal of manure and waste varies according to production system. Usage is generally low with less than 10% of the animal manures and crop residues available to smallholder farmers in Ethiopia applied to soils (Nigussie et al. 2015). Some smallholders use livestock manure to fertilize farmlands, and cow dung is made into cakes and used as a fuel or used for house plastering, or it is sold for income (Tesfay, 2014). A study in Ada'a district of Oromia in central Ethiopia showed that 93% of survey respondents collected manure for household fuel and 24% of them sold it to get additional income; in 99% of the cases, manure is sold by women (Minase, 2013).

Intensive commercial dairy and beef farms lack integrated waste management systems (Belete, 2015). The extent of the consequent slurry/manure disposal problem depends on the number of animals raised, property size, and location of the farm. For instance, a study in the central zone of Tigray in northern Ethiopia revealed that 36% of urban dairy farms experience waste disposal problems compared to less than 14% of peri-urban dairy farms (Tesfay, 2014). In the Shashemene-Dilla milkshed in southern Ethiopia, 47% of urban dairy producers spent additional money to dispose of cow dung from their farms (Tegegne et al., 2013). Although the use of animal waste for biogas production has increased in the country, it is still limited mostly due to lack of funds to purchase the equipment (Kamp and Bermudez Forn, 2016; Gedefaw, 2015; NBP, 2007).

Livestock Production Constraints

Livestock development in Ethiopia is constrained by both technical and institutional factors. Limiting institutional factors include poor linkages between technology sources such as research centers and end users, and limited extension and financial services (MOA, 2013). The technical constraints include insufficient and low-quality feed, widespread prevalence of diseases, as well as poor genetic makeup of the animals, in part due to unavailability or prohibitive prices of improved breeds. According to CSA (2020), 97.8% of cattle, 99.6% of sheep, 81.7% poultry, and almost all goats (99.9%) in the country are indigenous breeds that have relative poor productivity and reproductive performance. The average daily milk production and lactation length for a local cow are 1.5 liters/day over seven months, respectively; production and lactation length are relatively better for camels at 5.16 liters/day and nine-months, respectively. The mean age at first calving and the calving interval are around 50 and 22 months, respectively (Duguma et al., 2012). The mean annual egg production is 45 eggs per hen. Improved bulls are largely unavailable and artificial insemination (AI) service is insufficient and inefficient, despite high demand for it (Melesse et al., 2020; Tegegne et al., 2013; Yami, 2012).

Feed demand vastly exceeds feed supply, especially in years of drought (MOA, 2015). The dominant feed resource is poorly managed roughage with low nutritional value. Improved feed accounts for only 0.7% of the total feed available in the country (CSA, 2020), and the price of concentrates is high. Feed availability is seasonal and producers/farmers lack knowledge to conserve extra feed during the wet season for the dry season (Duressa et al., 2014). In addition, feed production is affected by shortage of land. Increased cropping and urbanization have resulted in encroachment on grazing lands, particularly in the highland mixed farming areas. For instance, grazing land in northwestern Ethiopia declined by 30.5% from 1986 to 2013 (Amsalu and Addisu, 2014). Credit services for livestock development are inadequate because the amount provided is small, the procedures to get the credit are complex, and producers lack awareness of the opportunities and their importance (Duressa et al., 2014; Tegegne et al., 2013; Yami, 2012). Women have less access and are considered less creditworthy than their male counterparts for various reasons (Yisehak, 2008). Moreover, the livestock mortality rate is very high; the death estimates for 2020 fiscal year were 3.11 million cattle (4.8%), 5.52(13.8%) million sheep, 0.22 (2.75%) million camels, and 34.71 (70.8%) million chickens (CSA, 2020). These estimates do not include the non-sedentary (nomadic) areas of the country.

Major Livestock Diseases

In Ethiopia, there are several endemic animal diseases caused by bacteria, viruses, protozoa, and parasites that compromise the productivity of livestock. The most important diseases are listed below.

Foot and Mouth Disease (FMD)

Foot and Mouth Disease (FMD) is endemic in Ethiopia and outbreaks occur in cattle throughout the country. Dabasa and Aduna (2021) reported seroprevalences between 9%-26% at the animal level and up to 48% at the herd level in cattle, whereas Abdela (2017) reported a seroprevalence of FMD from 5.6% up to 42.7% in cattle. Among the seven globally known serotypes of FMD virus, serotypes O, A, and SAT2 were identified in Ethiopia between 2008 and 2019 related to two niches of FMD virus circulation in East Africa: one extending across the northern areas and comprising Ethiopia, Eritrea, Somalia, Sudan and Southern Sudan, and the second one covering Kenya, Tanzania and Uganda in the south. (Gizaw et al., 2020).

The estimated economic losses due to FMD outbreak in cattle arising from milk loss, mortality, and draft power loss, average US\$76 per affected herd, US\$9.8 per head in crop-livestock mixed systems, and US\$174 per affected herd and US\$5.3 per head in the pastoral system (Jemberu et al., 2015). In another study, the overall short-term farm level direct loss due to FMD outbreak in an urban dairy farm was estimated at ETB 45,131, equivalent to €1,962 (Beyi, 2012). Data on national level economic impact of FMD is lacking. It appears that the prevalence of FMD is highest in intensive production systems, somewhat lower in mixed farming systems, and lower still in pastoral systems. For instance, animal level prevalence in Borena (pastoralism) (Rufael et al., 2008), Bahir Dar (mixed farming) and Haramaya (intensive production), East Hararge zone (Negussie et al., 2011) were 21%, 38.4%, and 80%, respectively.

Lumpy Skin Disease (LSD)

Lumpy Skin Disease (LSD) is an endemic viral disease of cattle in Ethiopia. Herd-level prevalence of LSD has been reported to be 44% (38-50%), with the highest prevalence in the mid-highlands (64%), followed by the lowlands (50%). Animal-level prevalence in infected herds is 27% (22-32%), with 31% in the mid-highlands, 24% in the highlands, and 23% in the lowlands (Gari *et al.*, 2012). Molla *et al.* (2017) reported that the morbidity was significantly higher in the intensive (17.5%) compared with the crop–livestock (10.1%) system. The mortality was also significantly higher in the intensive (4.0%) than in the crop–livestock (0.7%) system. An LSD outbreak investigation report showed that 108 of 296 affected cattle in one area (13.61% of all animals) died in two outbreaks, which was roughly worth ETB972,000 (US\$51,590) in direct financial loss plus an additional expense of ETB16.50 per animal for treatment (Ayelet *et al.*, 2012). Furthermore, annual financial costs of LSD were estimated by adding average production losses stemming from morbidity and mortality (for milk and beef production and draft power losses) to treatment and vaccination expenses; the economic cost in infected herds was US\$6.43 (5.12-8) per head of local breed and US\$58 (42-73) per head of Holstein-Friesian/crossbred cattle (Gari *et al.*, 2011).

Contagious Bovine Pleuropneumonia (CBPP)

Contagious Bovine Pleuropneumonia (CBPP) is an endemic bacterial disease of cattle in Ethiopia with a seroprevalence that ranges from 0.4 to 96% reported from different export quarantine centers and production areas in the country. The reported seroprevalence is significantly associated with different agro-ecologies of the country, and the highest was reported for the lowlands, where 40% of the livestock population are kept (Abdela and Yune, 2017). Ethiopia loses over ETB 205.6 million per year due to CBPP (Laval, 1999). The case fatality rate of CBPP is estimated at 16% (Gulima, 2011, cited in EAHYB, 2012).

Bovine Tuberculosis (BTB)

Bovine Tuberculosis (BTB) is endemic in Ethiopia, with low prevalence in the extensive system varying from 0.3% to 5.5% at the animal level (Tschopp et al., 2013; Gumi et al., 2012; Gumi et al., 2011), and high prevalence in urban and peri-urban dairy farms—55% at herd-level and 32.3% at animal level (Firdessa et al., 2012). The prevalence of BTB in cattle slaughtered in abattoirs has been 0.83-5.2% (Mengistu & Enquselassie, 2014; Shitaye et al., 2007), and the carcasses of 0.024-0.03% of cattle slaughtered in some

abattoirs were completely condemned (Mummed & Webb, 2015; Asseged et al., 2004). There is no data on production losses, but the prediction of economic losses based on current BTB prevalence in the country and loss of weight reported by farmers implies that it causes substantial losses to the producers and the livestock sector (Tschopp et al., 2013).

Brucellosis

Brucellosis is a zoonotic infection caused by the bacterial genus *Brucella*. The bacteria are transmitted from animals to humans by ingestion through infected food products, direct contact with an infected animal, or inhalation of aerosols. The disease is an old one that has been known by various names, including Mediterranean fever, Malta fever, gastric remittent fever, and undulant fever. Humans are accidental hosts, but brucellosis continues to be a major public health concern worldwide and is the most common zoonotic infection. A meta-analysis by Tesfaye et al. (2021) reported high seroprevalence in Southern Ethiopia of 8% on average (4.0- 12.0%) followed by Northern Ethiopia at 3% on average (1.0- 7.0%), whereas the least prevalence was observed in Central Ethiopia at 1% (0.0- 3.0%) and Eastern Ethiopia at 1% on average (1.0- 3.0%). Brucellosis has both public health and economic impacts. There is no data on the economic impacts of brucellosis on livestock production in Ethiopia; however, Megersa et al. (2011) reported a significant association between seropositivity and a history of spontaneous abortion in cattle herds. Unlike BTB, the prevalence of brucellosis was lower in intensive production systems than in the extensive system (Asmare et al., 2013; Tschopp et al., 2013; Megersa et al., 2011;). Husbandry practices of commingling animals from different herds together, such as aggregation of animals at watering points in pastoral areas, favors the spread of brucellosis (Yohannes et al., 2013; Megersa et al., 2011; Jergefa et al., 2009).

Contagious Caprine Pleuropneumonia

Contagious caprine pleuropneumonia (CCPP) is a contagious disease caused by *Mycoplasma capricolum subspecies capripneumoniae* that causes severe fibrinous pleuropneumonia of goats characterized by respiratory distress, coughing, nasal discharge and high mortality rate. According to a meta-analysis of CCPP in Ethiopia by Asmare et al. (2016), the pooled prevalence estimate was 25.7% (20.9%-31.0%). The prevalence for samples collected at abattoir was 39.2%, while that of samples collected at field level was 22.4%.

Peste des Petits Ruminants

Peste des Petits Ruminants (PPR) is a viral disease of sheep and goats that is endemic in Ethiopia. In a countrywide study that covered 43 districts, the prevalence of PPR in sheep and goats was 6.4%, with the lowest prevalence in Oromia region (1.7%) and the highest in Somali region (21.3%) (Waret-Szkuta et al., 2008). Gari et al. (2017) reported PPR seropositivity of 48.43% in East Shewa and Arsi Zones, Oromia Region. Vaccination is an integral part of the Ethiopian efforts to eradicate the disease as part of the Global PPR Control and Eradication Strategy.

Pox

Sheep and goat pox are viral diseases characterized by fever, generalized papules or nodules, vesicles (rarely), internal lesions (particularly in the lungs), and death. Both diseases are caused by strains of capripoxvirus, all of which can infect sheep and goats. There is limited literature on the prevalence and trends of caprine and ovine pox in Ethiopia; however, it is thought to be common. Fentie *et al.* (2017) reported that in the Amhara region, seroprevalence varied between 11.9% in North Gondar and West Gojjam zones and 20.9% in South Gondar. Female and young animals were at higher risk than their counterparts.

Trypanosomiasis

Trypanosomiasis is a parasitic disease caused by species of flagellate protozoa belonging to the genus *Trypanosoma* which inhabit the blood plasma and various body tissues and fluids. These parasites are found in many animals but seem to be pathogenic only for mammals, including man. Trypanosomiasis is endemic in Ethiopia, particularly in southwest, west, and northwest areas. Trypanosomiasis prevalence in southwestern Ethiopia was 9.61%. (Duguma et al., 2015). Camels are affected by *Trypanosomiasis evansi* and the prevalence ranges from 2% to 10.9% in Afar and southern Oromia (Fikru et al., 2015, Tekle and Abebe, 2001).

Endoparasites

Endoparasites are parasites which live inside a host and generally inhabit areas such as the gut, lungs, heart and blood vessels. They are very common in all species across the country. The challenge of endoparasites is higher in the extensive production systems than in the intensive systems (Emiru et al., 2013; Duguma et al., 2012; Regassa et al., 2006). According to Biff et al. (2006), Ethiopia loses US\$81.8 million per year due to mortality caused by endoparasites. Based on a retrospective study of data collected over 15 years (1985-1999), Fromsa and Jobre (2012) estimated that the annual financial loss due to bovine hydatidosis (Echinococcus disease) arising from condemned organs, decreased carcass weight, and decreased milk yield was ETB 1.691 billion (US\$101.20 million). This is equivalent to ETB475.40 (US\$28.45) per infected slaughtered bovine and ETB249.00 (US\$14.90) per infected milking cow (Fromsa & Jobre, 2012). In Sodo municipal slaughterhouse, the annual loss resulting from bovine liver condemnation due to *Fasciola hepatica* was US\$4,000 (Abunna et al., 2010).

Ectoparasites

Ectoparasites are parasites which inhabit the skin or coat of the host animal. National surveys on ectoparasites are lacking in Ethiopia. Prevalence rates for ectoparasites ranging from 15.4%-40.2% were reported from various parts of the country (Onu et al., 2013; Yacob et al., 2008a; Yacob et al., 2008b). In central Ethiopia, the overall prevalence of ectoparasites in sheep was 48.1% (Kumsa et al., 2012). Ectoparasite control programs have been conducted in selected regions for some years; nevertheless, the prevalence does not appear to be declining (Tolossa, 2014). Ectoparasites are major causes of skin rejection at tanneries (Tolossa, 2014). The annual financial loss in a single tannery due to quality deterioration of exported skins was estimated at US\$778,199.41 for pickled sheep skins and US\$247,677.61 for wet blue goat skins (Ashenafi et al., 2014).

Newcastle Disease

Newcastle Disease (NCD) is an endemic viral fowl disease in Ethiopia. Fragmented studies conducted on village or backyard chickens have shown seroprevalence varying from 5.61-9.78% (Chaka et al., 2012; Zeleke et al., 2005).

Infectious Bursal Disease

Infectious bursal disease (IBD), also known as Gumboro disease, is a highly contagious, immunosuppressive disease of young chickens. The overall prevalence of Infectious IBD in Ethiopian chickens is 77.48% (EAHYB, 2012). In backyard chickens sampled at markets in central Ethiopia, the prevalence was 91.9% in the dry season and 96.3% in the wet season (Chaka et al., 2012). A follow-up study conducted for six months in two districts in northwest Ethiopia revealed cumulative incidence rates of 17.40% and 38.39% and case fatality rates of 77.73% and 98.56% in village chickens of Farta and Bahir Dar Zuriya districts, respectively (Mazengia et al., 2009). In an outbreak occurring in commercial poultry farms in Bishoftu, central Ethiopia, a mortality rate of 49.89% was reported (Zeleke et al., 2005).

Emerging Diseases

While outbreaks of Rift Valley Fever (RVF) occasionally occur in neighboring countries, clinical cases have not been reported in Ethiopia (EAHYB, 2012) despite the endemic status of the disease in Kenya. Southern Ethiopia has the highest risk for RVF (Anyamba et al., 2009). Occurrence of the ECF vector (*Rhipicephalus appendiculatus*) has not been reported in Ethiopia; however, the climate of central and southern parts of the country is favorable for this tick, and its introduction to the country could be disastrous to the cattle industry (Leta et al., 2013). An epidemic wave of an acute and contagious unknown camel syndrome, which is commonly called “Camel Sudden Death” (CSD), has been reported since 2005 when it was first reported in Afar. Since then, it has spread to the southern parts of Ethiopia and into Somalia and North Kenya in the subsequent years. This disease is not known to the local people, and the causative agent has not been identified (Megersa et al., 2012; Dawo, 2010). Serological testing was recently conducted on 188 camels from Afar, Somali, and Borena for detection of antibodies against Middle East Respiratory Syndrome Corona Virus (MERS-CoV); 93% of young and 97% adult camels were positive (Reusken et al., 2014).

Highly Pathogenic Avian Influenza virus (HPAI) has not been detected in Ethiopia. However, there is high risk of introduction of this virus because of the millions of birds migrating to East Africa from Europe and Asia each year to reach the lakes and wetlands in the Great Rift Valley. Given the risk posed by HPAI, a multidisciplinary national committee was established in 2005 and it has been carrying out vigilance through active surveillance with the concerned bodies of the government (EAHYB, 2012; Berhane and Tefera, 2005).

Zoonotic Diseases

Based on a systematic review of studies done between 2002 and 2011, *Mycobacterium bovis* was isolated from 23 of 342 milk samples (6.7%) collected from farms (Mengistu & Enquselassie, 2014). *M. bovis* was also detected in 21 of 449 samples taken from human tuberculosis (4.7%) and accounted for 7.24% of the total species of Mycobacterium isolated from human cases (i.e., total = 290). A seroprevalence study among human patients with febrile illness and *Brucella abortus* antibodies conducted in pastoral areas showed that 34.9% of patients in Borena zone, 29.4% of patients in Hamar district, South Omo zone, and 3% of patients in Metema district, North Gonder zone, were seropositive (Regassa *et al.*, 2009). It was also reported that 4.8% of abattoir personnel and dairy farmers in Addis Ababa were seropositive (Kassahun *et al.*, 2006). While *M. bovis* is occasionally isolated from human tuberculosis (TB) patients, it can be excluded as the predominant cause of the high national incidence of human tuberculosis (Firdessa *et al.*, 2013).

Based on retrospective data, 35.2% of cattle, 11.8% of sheep, 4.9% of goats, and 16.8% of camels slaughtered in 21 different abattoirs harbored hydatid cysts (*Echinococcus*; Fromsa and Jobre, 2012). In dogs, the prevalence of Echinococcosis varied from 20 to 50%; however, this estimate was based on a small sample size (Koskei *et al.*, 2011). In humans, an incidence of 2.3 cases of Echinococcosis per 100,000 per year was estimated based on a review of 36,402 patients admitted for an ultrasound examination (Kebede *et al.*, 2010).

A 2020 meta-analysis on the identification of risk areas and practices showed that the average zonal prevalence of meat inspection-based biliary-cyst communication ranged from 2% in Buno-Bedele to 24.6% in Sidama zone. The pooled prevalence of bovine tapeworm (*Taenia saginata*) was influenced by the number of muscle/organs inspected, ranging from 3.4% (95% CI: 1.7-5.1%) using fewer predilection sites to 19.4% (95% CI: 13.3-25.4%) using inspection of a maximum number of predilection sites. Questionnaire-based prevalence of taeniosis was higher in adult men with a frequent raw beef consumption habit (Jorga *et al.*, 2020).

Eighty-seven cases of human rabies were diagnosed by the Ethiopian Public Health Institute from 2015 to 2019 with 100% case fatality. Of these, 83 (95.4%) cases were attributed to dog bites, whereas 1 (1.1%) to a cat and 3 (3.4%) to wild animals. The fatalities were from Oromia ($n = 51$ (58.6%)), Amhara (13 (14.9%)) Addis Ababa (15 (17.2%)) and the Southern region (8 (9.2%)) (Aklilu *et al.*, 2021).

Government reports indicated 5197 and 26,737 cases of anthrax (*Bacillus anthracis*) for the period 2009-2013, and 86 and 8523 deaths in humans and animals, respectively (Bahiru *et al.*, 2016). The real burden of the disease in animals and humans is likely higher due to a generalized lack of knowledge about the disease, as shown by Romha and Girmay (2020) and Seid *et al.* (2020).

There are no recent reports of leptospirosis in livestock from Ethiopia; however, leptospiral antibodies were detected more than four decades ago in horses (91.3%), cattle (70.7%), pigs (57.1%), goats (47.3%), sheep (43.4%), camels (15.4%), and dogs (8.3%) (Moch *et al.*, 1975). The first human leptospirosis case in Ethiopia was reported from central Ethiopia, where 47.5% of febrile patients of unknown causes ($n = 59$) were positive for leptospiral infection (Yimer *et al.*, 2004).

The existence of *Coxiella burnetii* in Ethiopia, the cause of Q fever, was first reported in 1966 (Philip *et al.*, 1966). In 1988, 6.5% of 465 sera collected from people in Addis Ababa were positive for Q fever (Abebe, 1990). However, with a different detection method, Gumi *et al.* (2013) reported seroprevalence *Coxiella* of 31.6% in cattle, 90.0% in camels, and 54.2% in goats from southeast pastoral parts of Ethiopia.

Toxoplasmosis is highly prevalent in both animals and humans in Ethiopia (Dubey, 2013). Based on a meta-analysis, the prevalence of toxoplasmosis was 87.72% (8.63%-93.28%) in cats; 34.59% (21.08%-51.12%) in small ruminants; and 74.73% (61.85%-84.36%) in cattle (Gebremedhin & Tadesse, 2015). The prevalence in humans was 74.73%, with significantly higher odds of seroprevalence in pregnant women (3.96; 3.15% - 4.97%) than in nonpregnant women. Data on congenital toxoplasmosis in children is scarce, although Alemayehu et al. (2021) reported three clinical cases of congenital toxoplasmosis.

Priority Zoonotic Diseases

Ethiopia has committed itself to controlling five prioritized zoonotic diseases (rabies, anthrax, brucellosis, leptospirosis, and echinococcosis), using a One Health approach (Murphy et al., 2019). The National One Health Steering Committee (NOHSC) provides a framework for national stakeholders to address gaps in multisectoral communication, coordination and collaboration. In addition, the NOHSC oversees the formation of several specialized disease-focused groups, referred to as Technical Working Groups.

Factors Affecting Disease Incidence

Factors such as management practices, feed quantity and quality, cross-border movement, intensification of management and genetics, and climate influence livestock disease incidence in Ethiopia.

Management factors that increase the incidence of animal diseases in Ethiopia include mixing different species, commingling at watering points, and lack of knowledge on disease management practices (e.g., segregating sick animals, avoiding immediate mixing of new and existing animals, replacement practices, seeking traditional healers or doing nothing when the animal becomes sick, and not burning or burying dead animals) (Hailu et al., 2014; Megersa et al., 2009; Tschopp et al., 2009).

As previously mentioned, due to encroachment of crop cultivation and urbanization, grazing and rangelands are dramatically decreasing in Ethiopia. Consequently, the feed resource base in terms of both quality and quantity is declining, which in turn leads to susceptibility of animals to various infectious pathogens and parasites. Recurrent drought also exacerbates the occurrence of diseases (Addis et al., 2014; Catley et al., 2014). Cross-border movement, lack of quarantine, and unrestricted animal movement in the country are factors in disease incidence (Megersa et al., 2009).

Intensification of production and the distribution of improved breeds of chickens, or of chickens infected at breeding or multiplication centers, contribute to the incidence and spread of chicken diseases (Mazengia, 2012; Mazengia et al., 2009). These factors also hold true for large animal diseases, such as BTB (Vordermeier et al., 2012; Ameni et al., 2007); FMD (Negussie et al., 2011; Rufael et al., 2008); LSD (Gari et al., 2011); and brucellosis (Tschopp et al., 2013; Firdessa et al., 2012). Global warming and micro-agro-climatic change induced by factors like development of hydroelectric dams and irrigation schemes are contributing to changes in the incidence patterns of vector-borne and other diseases and external and internal parasites (Alemayehu & Fantahun, 2012).

Priorities for Disease Control

In Ethiopia, priority is given to decreasing the morbidity and the mortality of production related diseases (mainly external and internal parasites); to trade-limiting diseases (FMD, ovine/caprine pox, LSD, PPR, CBPP); and to prevention of highly pathogenic emerging diseases (RVF, HPAI/NCD complex, ECF). In the Ethiopia Livestock Master Plan (Shapiro et al., 2015), diseases have been prioritized based on their impacts on rural households, impacts on market and value chains, and possibilities for intensification pathways for control schemes. Accordingly, the diseases with the top priority ranks are FMD, CBPP, brucellosis, and tuberculosis for cattle; PPR, ovine/caprine pox, and CCPP for small ruminants; surra (trypanosomiasis) for

camels; and NCD for chickens. In addition, trypanosomiasis and external parasites are included in the priority list.

The occurrence of transboundary diseases, such as FMD, CBPP, CCPP, PPR, brucellosis, and LSD affect access to international trade. Due to these diseases, Ethiopia is denied the opportunity to export live animals or meat to the lucrative European market. Furthermore, trade with Middle East countries is frequently hampered and embargos are sometimes imposed due to such diseases (AGP-LMD, 2013b). Depending on the importing country's requirements, animals are screened and/or vaccinated for specific diseases during a quarantine period. For instances, United Arab Emirates (UAE) requires sheep and goats be screened for brucellosis and RVF, while Egypt wants animals screened for FMD, CBPP, and brucellosis. Ethiopia lost more than US\$14 million due to an FMD-related import ban by Egyptian authorities in 2005/2006 (Leforban, 2005). Feedlot animals that recovered from LSD are not fit for export purposes and thus must be sold on the local market for lower prices (Ayelet, 2014). A clinical case of RVF has not been reported in Ethiopia, despite occasional outbreaks in the neighboring countries (EAHYB, 2012), Nevertheless, exports are limited because live-animal importing countries like UAE request sheep and goats that are serologically negative for antibodies against RVF virus (AGP-LMD, 2013a; AGP-LMD, 2013b).

Human Health, Food Safety & Diets and Nutrition (AOI #2)

Nutrition Indicators

Between 2000 and 2019 the prevalence of stunting in children under 5 years of age declined from 58% to 37%, although further reductions are needed to achieve 2030 targets. Prevalence of stunting among children under 5 is estimated to be 36.8% although there are strong regional differences, see Table 5 (EPHI & ICF, 2019).

Table 5. Prevalence of Stunting by Region

Region	Stunting prevalence
Tigray	48.7%
Afar	43.0%
Amhara	41.3%
Oromia	35.6%
Ethiopia Somali	30.5%
Benishangul Gumuz	40.8%
SNNP	36.3%
Gambela	17.6%
Harari	34.7%
Addis Ababa	13.9%
Dire Dawa	25.4%

Source: EPHI & ICF, 2019

Animal-Source Food Consumption

According to CSA (2020b), out of the total annual milk production, 50% was used for household consumption, 10% was sold, only 0.56% was used for wages in kind, and the rest (39%) was used for other purposes (such as to produce butter, cheese, yogurt, etc.). For butter, 55% of the production was used for household consumption although a considerable portion (39%) was sold. Most of the total cheese produced was used for household consumption (57%), 17% was sold, and the rest (6%) was used for wage in kind and other purposes (Table 3).

The average per capita protein consumption from eggs (0.11– 0.13 g/capita/day) and poultry meat (around 0.22 g/capita/day) from 1961-2013 was very low (FAO, 2019). Hirvonen and Wolle (2019) estimated that consuming 2.5 eggs per week per person (i.e., 13 grams per person per day) would cost approximately 4% of the total consumption budget for the average household in Tigray. For the poorest quintile, the corresponding budget share is 10%. The high price of animal-source foods (ASF) is a major concern. Bachewe *et al.* (2017) analyzed ASF price patterns in the last decade (2007-2016), relying on a large-scale price dataset collected in 116 urban retail markets in Ethiopia. In addition to important seasonal and spatial patterns, the authors revealed that real prices of ASF have been increased in the last decade by between 32 to 36% for three major ASF – milk, eggs, and meat. Similar price increases were evident in rural and urban areas and for tradable and non-tradable ASFs. This price trend is in contrast with staple cereals for which real prices stayed at similar levels over the last decade.

Abegaz *et al.* (2018) assessed patterns and changes in ASF consumption using unique nationally representative household consumption data sets from 1995/96 to 2010/11. Main findings include:

1. While ASF consumption is low overall in Ethiopia, real expenditures on ASF have increased by 50% over the 15-year period;
2. Per capita ASF consumption increased but significantly less than ASF expenditures because of relative price increases of ASF over this period;
3. Expenses on dairy products make up almost half of all ASF expenditures;
4. The share of ASF expenditures in the total food budget for the richest quintile is three times higher than for the poorest quintile;
5. Residents in urban areas spend twice as much on ASF per capita than rural residents; and
6. There is significant variation over the year in ASF consumption, seemingly associated with religious customs.

The study also found strong effects of prices and incomes on ASF consumption levels. Therefore, keeping prices low and stimulating further income increases are important factors to improve low ASF consumption in Ethiopia. Using reasonable assumptions on income growth, urbanization, prices, and marketization, it estimates that national ASF consumption and commercial markets will increase by 165% and 192% by 2030 respectively and that the size of urban commercial markets will quadruple by 2030.

Foodborne Disease

National data are lacking on the burden of foodborne diseases; however, various fragmented studies show high prevalence of pathogens in foods of animal origin, in animals, and in humans. A literature review by Keba *et al.* (2020) on the prevalence of major bacterial foodborne pathogens (*Salmonella* spp., *Listeria monocytogenes*, *Escherichia coli* O157:H7 and *Campylobacter* spp.) in the Ethiopian dairy supply-chain reported a high median prevalence of *Salmonella*, *L. monocytogenes*, and *E. coli* O157:H7 of 6, 9 and 10%, respectively, in raw cow milk.

The overall prevalence of *Salmonella* in raw meat samples (beef, goat meat, mutton, pork, and camel) collected from abattoirs and markets varied. For abattoir samples, the prevalence was 5.6% whereas for markets the prevalence was 11.7%. In addition, 10.8% of milk samples from farms were positive. *Salmonella dublin*, *S. anatum*, *S. saintpaul*, *S. newport*, *S. typhimurium*, *S. infantis*, *S. mishmarbaemek*, *S. braenderup*, and *S. muenchen* have been isolated from the milk samples (Tadesse & Gebremedhin, 2015). Similarly, the pooled prevalence estimates of *Salmonella* in humans were 8.7% in diarrheic children, 5.7% in diarrheic adults, and 1.1% in carriers; 57.9% of the isolates were nontyphoidal *Salmonella*. Two of nontyphoidal *Salmonella* serotypes (*S. concord* and *S. paratyphi*) and two typhoidal serotypes (*S. typhimurium* and *S. typhi*) accounted for 82.1% of the isolated major serotypes that cause human infections (Tadesse, 2014). *Salmonella* was also isolated from 3.1% of food handlers in Gonder (Garedew-Kifelew *et al.*, 2014).

Mengesha et al. (2009) analyzed ready-to-eat food items (pasteurized milk, cheese, ice cream, and cakes) and raw meat products (minced beef, pork, and chicken carcasses) in Addis Ababa. Of the 711 food samples examined, 189 (26.6%) were *Listeria* positive, of which 34 (4.8%) were *L. monocytogenes*. Pork was the most contaminated with *Listeria* species (62.5%) followed by minced beef (47.7%), ice cream (42.7%), soft cheese (16.8%), chicken carcasses (16.0%), and creamed cakes (12.1%). All pasteurized milk and cottage cheese samples examined were *Listeria* negative.

A meta-analysis of the prevalence of *Escherichia coli* in foods of animal origin in Ethiopia by Assefa and Bihon (2018) found overall random pooled prevalence of 15% (13%–17%) in foods of animal origin. A meta-analysis by Zenebe et al. (2020) on the prevalence of *Campylobacter* spp. in humans, animals, and food of animal origin and their antimicrobial susceptibility in Ethiopia showed that the pooled prevalence of *Campylobacter* spp. from different sources was 10.2% (3.79%–16.51%). In this meta-analysis, the lowest prevalence was 6.0% whereas the highest prevalence was 72.7%. Prevalence of *Campylobacter* was higher in animals (14.6%) compared to humans (9%). The pooled antimicrobial resistance rates of *Campylobacter* spp. to different antimicrobials ranged from 2.9–100%.

A cross-sectional study by Chen et al. (2021) involving 102 randomly selected children between 12 and 16 months of age conducted in rural eastern Ethiopia in 2018 found that the prevalence of *Campylobacter* colonization was 50% (41–60%) by polymerase chain reaction (PCR). In addition to the thermotolerant species *Campylobacter jejuni*, *Campylobacter coli* and *Campylobacter upsaliensis*, non-thermotolerant species related to *Campylobacter hyointestinalis* and *Campylobacter fetus* were frequently detected by Meta-total RNA sequencing (MeTRS). The prevalence of Environmental Enteric Dysfunction (EED) and stunting was 50% (95% CI: 40–60%) and 41% (32–51%), respectively. Among enrolled children, 56% had consumed some ASF in the previous 24 hours; 47% had diarrhea and 50% had fever in the past 15 days. The researchers found 54, 63, 71 or 43% of households owned at least one chicken, cow/bull, goat, or sheep, respectively; 54 (53%) households kept chickens indoors overnight and only half of these confined the animals. Sanitation was poor, with high levels of unimproved latrines and open defecation. Most households had access to an improved source of drinking water. The same study team demonstrated that (1) in addition to *C. jejuni* and *C. coli*, multiple non-thermophilic *Campylobacter* spp. (i.e., *Campylobacter hyointestinalis*, *Campylobacter fetus*, and *Campylobacter concisus*) were frequently detected in the children's stools and (2) the *Campylobacter*, gut permeability, gut inflammation, EED severity, and diarrhea were associated with characteristic microbiome composition (Terefe et al., 2020).

The global report of the Foodborne Disease Burden Epidemiology Reference Group (FERG, a World Health Organization external advisory group) reported that Ethiopia is in a subregion that experiences the second highest foodborne disease burden in the world (Havelaar et al., 2015). Diarrheal disease agents such as Norovirus, *Campylobacter* species, *E. coli*, *Salmonella* species, and *Cryptosporidium* species contributed to the largest part of the foodborne disease disability adjusted life years (DALYs) in this region (Table 7).

Table 6. Median rates of Disability Adjusted Life Years (DALYs) per 100,000 Population Due to Foodborne Diseases for Africa Sub-region E, including Ethiopia (with 95% uncertainty intervals), 2010 (Source: Havelaar et al., 2015).

All hazards	DALYs	Causes	DALYs	Causes	DALYs
Diarrheal disease agent	824 (447-1,326)	Invasive infectious disease agents	147 (55-343)	Helminths	184 (141-240)
Viruses	76 (0-225)	<i>Viruses</i>		<i>Cestodes</i>	178 (136-235)
Norovirus	76 (0-225)	Hepatitis A virus	18 (3-55)	<i>E. granulosus</i>	0.8 (0.2-16)
Bacteria	712 (393-1,160)	<i>Bacteria</i>	104 (40-277)	<i>E. multilocularis</i>	0(0-0)
<i>Campylobacter</i> spp.	70 (33-177)	<i>Brucella</i> spp.	0.3 (0.007-18)	<i>Taenia solium</i>	176 (134-229)

All hazards	DALYs	Causes	DALYs	Causes	DALYs
Enteropathogenic <i>E. coli</i>	138 (6-327)	<i>L. monocytogenes</i>	1 (0-21)	<i>Nematodes</i>	5 (1-11)
Enterotoxigenic <i>E. coli</i>	105 (17-240)	<i>M. bovis</i>	34 (21-48)	<i>Ascaris</i> spp.	5 (1-11)
Shiga toxin producing <i>E. coli</i>	0.08 (0.02-0.2)	<i>S. Paratyphi A</i>	12 (0-43)	<i>Trichinella</i> spp.	0.001(0-0.002)
Non-typhoid <i>S. enterica</i>	193 (44-336)	<i>S. Typhi</i>	52 (0-187)	<i>Trematodes</i>	0.02(0.008-0.07)
<i>Vibrio cholera</i>	143 (4-383)	<i>Protozoa</i>	20 (9-37)	<i>Clonorchis sinensis</i>	0(0-0)
Protozoa	21 (5-66)	<i>Toxoplasma gondii</i>	20 (9-37)	<i>Fasciola</i> spp.	0.01(0.005-0.04)
<i>Cryptosporidium</i> spp.	12 (0-45)	Chemical and toxins	7 (3-21)	Intestinal fluke	0(0-0)
<i>Entamoeba histolytica</i>	5 (0-41)	Aflatoxin	3 (1-8)	<i>Opisthorchis</i> spp.	0(0-0)
<i>Giardia</i> spp.	0.7 (0-3)	Cassava cyanide	1 (0.3-9)	<i>Paragonimus</i> spp	0.008(0.002-0.02)
		Dioxins	0.2 (0.09-9)		
Total DALYs 1,179 (726-1,764)					

A follow up study by Li *et al.* (2019) assessed the global human disease burden associated with 13 pathogens (bacteria and parasites) in ASF. In 2010, the global burden of ASF was 168 (137–219) DALYs per 100,000 population, which is approximately 35% of the estimated total burden of foodborne disease (FBD). Main pathogens contributing to this burden included non-typhoidal *Salmonella enterica*, *Taenia solium*, and *Campylobacter* spp. The median ASF burden in all sub-Saharan countries, African subregions AFR D and E (which includes Ethiopia), was 580 (314–879) and 459 (294–625) DALYs per 100,000 population, respectively, a burden that is remarkably higher than those reported elsewhere.

In Ethiopia, several factors have been associated with the incidence of foodborne and zoonotic diseases. These factors include poor sanitation and open defecation (Amenu *et al.*, 2014; Kebede *et al.*, 2009); backyard slaughter; the tradition of consuming raw milk (Tschopp *et al.*, 2013); raw or under-cooked meat (called “kitfo,” “dulet,” “kourt”; Kebede *et al.*, 2009; Tadesse & Gebremedhin, 2015); malnutrition and other endemic diseases like HIV-AIDS (Tadesse & Gebremedhin, 2015); poor implementation of food safety regulations and risk-based food safety systems (Jabbar, 2012); poorly equipped food processing plants and slaughterhouses; lack of awareness about foodborne and zoonotic diseases in the society (Amenu *et al.*, 2010); and lack of food storage facilities such as refrigeration, due to poor electricity coverage and unaffordable prices (Tadesse and Gebremedhin, 2015).

Markets and Innovation Translation (AOI #3)

Marketing and Trade

Dairy and Dairy Products

In Ethiopia, fresh milk, butter, fermented or soured whole milk (*ergo*), cottage cheese (*ayib*), and buttermilk (*arera*) are both formally and informally marketed (Gezu and Zelalem, 2018). The informal milk marketing system is dominant, accounting for 95% (Anteneh *et al.*, 2010) of marketing in the country, and producers directly sell their products to consumers or to unlicensed traders or retailers. Neither operational licenses or quality checks are used in the informal system (Yilma *et al.*, 2011). The formal marketing system prevails in peri-urban and urban areas; milk is collected from producers by cooperatives and private collection and processing plants, which channel the products to consumers, caterers, supermarkets, and retailers (Tegegne *et*

al., 2013; Anteneh et al., 2010). Under the formal system, the quality of the milk is tested for acidity and density on delivery (Yilma et al., 2011). In some urban areas where milk collecting cooperatives or milk processing plants are absent, such as Bako and Nekemte towns of Oromia in western Ethiopia, the marketing system is informal (Geleti et al., 2014a). In pastoral and agro-pastoral areas of eastern Ethiopia, milk from both cows and camels is sold in raw form through the informal marketing system (Demissie et al., 2014). In this area, cow milk is processed to butter, and sale of soured milk and butter account for around 10% of the total milk market, while camel milk processing to other dairy products is uncommon (Demissie et al., 2014). Besides raw milk, soured milk is also marketed in pastoralist areas like Borana in Oromia region. Milk and other dairy products generally are marketed in towns and marketplaces.

Actors in the milk marketing system are producers, cooperatives, local assemblers, wholesalers, retailers, and consumers. The type of actors and market channels between producers and final consumers vary from place to place and depend on the type of livestock production systems. In urban areas, producers sell their products directly to consumers or cooperatives or caterers (e.g., cafés, restaurants). In rural areas, producers sell their products to cooperatives or assemblers who then market to wholesalers, who sell to retailers that bring the dairy products to the end users (Geleti et al., 2014a; Tegegne et al., 2013; Anteneh et al., 2010;). Similar actors are present in eastern pastoral areas, although the existence of cooperatives was not reported from either the southern or the eastern pastoral areas (Demissie et al., 2014).

Minten et al. (2021) conducted during LSIL Phase I showed that with the growth in dairy consumption, the formalization of dairy markets, and growth in investments by dairy processing companies are rapidly increasing in Ethiopia. This growth is leading to the consumption of pasteurized milk; however, raw milk markets remain important. The same study indicated that in most of the marketing channels of the raw milk supply chain, no middlemen are involved, rather, urban retailers obtain the milk that they sell directly from the producers or from their own farms. This procurement model represents 60% of the raw milk supply to urban retail shops (Minten et al., 2021). For another 30% of the milk, a trader gathers the milk from farmers and delivers it to the shop; longer raw milk value chains are rare for raw milk. However, in the case of pasteurized milk, longer supply chains were observed. For 44% of the pasteurized milk, the structure was three nodes between farmers and retailers (i.e., farmers sell to rural traders, who deliver to dairy processing companies, which then distribute to urban retailers through independent distributors or traders). In 32% of the cases, there were only two nodes, which involved processing firms either collecting milk from farms or distributing the milk to consumers directly.

Ethiopia is not known for its dairy product exports; however, some insignificant quantities of milk and butter are exported to a few countries. Butter is mainly exported to Djibouti and South Africa (targeting the Ethiopians in diaspora), while milk is solely exported to Somalia from the Southeastern Region of the country. Small quantities of cream are also exported to Djibouti from Dire Dawa. The choice of targeting either domestic or export markets in the process of smallholder commercialization is basically linked to the nature of the targeted commodities (SNV, 2006). For countries with large populations, domestic markets could also be a major market target due to high demand for both staples and high-value commodities (Jaleta et al., 2009). In targeting smallholder products for export markets, product quality, sanitary and phytosanitary standards, timely and regular supply, and volume need emphasized to enable small-scale farmers to participate (Henson et al., 1999).

Ethiopia spent over 678.75 million birr (approximately 15 million US\$) to import various milk products from 2006-2010. Expenditure on powdered milk accounted for 79.6%, followed by cream at 12.9% and cheese at 4.3% (MOA and ILRI, 2013). With Ethiopia already spending approximately \$10 million annually on foreign powdered milk imports, there is a huge opportunity for domestic ultra-high-temperature (UHT) production.

Meat and Live Animals

As in the case of milk, meat and live animals are channeled through both formal and informal marketing systems, but the latter system is dominant. There are three channels in the domestic market: consumers buy live animals from a market and slaughter them themselves, or purchase meat from a market, or meat from butcher shops (Alemayehu, 2011). The actors in the live animal trade are producers, local traders, middle or larger scale traders, butchers, and consumers (Alemayehu, 2011). The main animal collection points for most export abattoirs and live animal exporters are purchasing agents assigned in major marketing areas, small and large scale traders, and livestock trading cooperatives (Asegede et al., 2015; Legese et al., 2008).

Beef, mutton, goat, and camel meat are sold in marketplaces and butcher shops. The domestic demand for meat increases during traditional and religious festivities. However, demand sharply declines during the fasting seasons of Orthodox Christianity, particularly in the 55 days before Easter festivities. Meat and live animals are exported to the Middle East and some African countries. Chilled/frozen beef, goat meat, mutton, chilled veal, chilled camel meat, and red offal are mainly exported to the United Arab Emirates (UAE), Saudi Arabia, Angola, Egypt, Bahrain, Turkey, and Kuwait. All of the exported meat is sold through formal channels, due to regulations of the importing countries. Live animals are exported to Somalia, Kenya, Sudan, Djibouti, Egypt, UAE, Saudi Arabia, and Yemen. Informal cross-border trade mostly consists of live animals (Alemayehu, 2011; AGP-LMD, 2013a; AGP-LMD, 2013b).

Poultry and Eggs

Poultry and egg markets in Ethiopia are at an early stage of development. The scavenging family poultry production systems are the principal providers for the domestic market, supplying most of the marketable poultry products. The share of the intensive and semi-intensive poultry systems in the national market is currently on the rise. The national poultry meat output in 2016 was estimated at about 13,000 tons. There are a few private large-scale commercial poultry farms in Ethiopia, most of which are located near the capital or regional towns. Alema Farms, ELFORA Agro-Industries, Ethiochicken, SAFE Poultry PLC, Astral Foods and Feedco Animal Feeds PLC are among the major companies importing breeding stock, supplying DOCs, and hatching eggs. ELFORA, Alema, and Genesis are the three largest commercial poultry farms with modern production and processing facilities (Matawork, 2016 in Alemneh, 2019). ELFORA is the largest and delivers around 420,000 chickens and over 34 million eggs annually to the market of Addis Ababa (Alemneh, 2019). Alema poultry farms is the second largest, delivering nearly half a million broilers to Addis Ababa market annually. Alema has its own broilers' parent stock, feed processing plants, hatchery, slaughterhouses, cold storage, and transportation facilities. The large commercial poultry farms provide fertile eggs, table eggs, day-old-chicks, broiler meat, and adult breeding stocks to the small-scale commercial poultry farms. The Alema hatchery produces 2.88 million broiler and layer DOCs per year; approximately half of the broiler DOCs produced are used for their own production, while the remaining half are sold to other farms. ELFORA can produce up to 112,000 DOCs per week. Although ELFORA has the largest DOC production capacity, SAFE Poultry PLC, which produces around 2 million DOCs per year, is the largest supplier of layer DOCs to small-scale intensive family poultry producers.

Ethiochicken is another company engaged in the introduction of parent stock and DOCs. It also operates through a tailor-made distribution model with the government by supplying 40-day-old, dual-purpose chicken to rural smallholder farmers. Ethiochicken's hatchery has the capacity of at least 2.4 million DOCs per year. Astral Foods PLC and Feedco Animal Feeds PLC also produce substantial numbers of broiler and layer DOCs each, with a hatching capacity of 50,000 DOCs per batch. None of these companies are apparently engaged in the supply of fertile hatching eggs (FAO, 2019b). Despite the growing production of broiler and layer DOCs, the total output of the Ethiopian hatcheries is still limited, and currently there is a severe shortage of DOCs in the country. Knowledge of the hatching process is low and management standards in most of the hatcheries are poor. In addition, the management of parent stocks is below global industry standards.

Ethiopia's share of the total poultry meat outputs in East Africa, Africa, and the world in 2016 was only 2, 0.2 and 0.01%, respectively (Table 7). Similarly, its share of total egg production is low when compared to East Africa, Africa, and world poultry egg production in the same year.

Table 7. Annual poultry meat production in Ethiopia as percentage share of African and global production, 2016

Country	Production (thousand tons)	Ethiopia (% share)
Ethiopia	13	--
East Africa	688	2
Africa	5,913	0.2
World total	120,302	0.01

Source: FAO, 2019

Poultry and poultry products are probably among the least traded commodities in Ethiopia. Despite the lack of consistent and reliable statistics, some sources indicate that Ethiopia has been importing parent DOCs for many years. All the breeding stock and DOCs used by largescale intensive poultry producers and government multiplication centers are imported. The country imported varying quantities of live chickens from 2003 to 2016. The largest quantity imported was in 2008 (398,000 heads), with no imports in the subsequent two years, and very small quantities imported afterwards (FAO, 2019). The only significant volume of chicken meat imported was 130 tons recorded in 2013. Relative to chicken meat, substantial volumes of canned chicken meat were imported between 2014 (193 tons) and 2016 (141 tons).

Ethiopia has no notable records of poultry egg importation and exportation or of exporting live poultry or processed chicken meat. The Ethiopian LMP was aiming to achieve exportable surplus of poultry meat by 2020. However, no documented report made available yet on export of poultry meat during this planned. The local demand for poultry meat and egg is rapidly increasing and exporting meat and eggs may not happen soon.

Market Information and Prices

Dairy and Dairy Products

Sources of market information in Ethiopia are government, dairy cooperatives and unions, and traders (Yilma et al., 2011). The market information from dairy cooperatives and unions, however, it is only distributed to their members. The real prices of dairy, eggs, and meat increased by over 32% over the decade between 2007 and 2016. This increase is in contrast with the real prices of grains, roots, and tubers, important components of the total food consumed, which at the end of 2016 were at the same level as at the beginning of 2007 (Bachewe et al., 2017). Season and distance from the main towns affect the price, with the price being higher both during dry seasons and closer to towns, where demand is high. Milk is transported from the local market places to the nearby towns by donkeys and light trucks (Tolera and Abebe, 2007).

Meat and Live Animals

The Ethiopian Livestock Market Information System (LMIS) provides regular livestock prices and volume information to producers, middlemen, and traders in most of the major livestock markets in the country. Information from LMIS is available online and upon request via text messaging and email.

Poultry and Eggs

According to FAO (2019b), large-scale farms use several routes to market the eggs they produce. These include sales through their own super/mini markets, sales to other super/mini markets, or direct sales to market vendors. Primary collectors are another route to the market, playing the role of middlemen in the distribution channel. The key market channels for small and medium-scale farms are primary collectors. The

latter collect the eggs from different farms and sell them to market vendors or super/mini markets. Consumers buy eggs from local markets as well as from kiosks and shops in villages or supermarkets in bigger cities. The general trend is that producer prices have slightly increased from 2006 to 2008 (FAO, 2019b). The trends in producer prices fluctuated until they showed sharp rises in 2016. Compared to 2006, the producer price per ton of hen eggs in shell increased five-fold in 2016, from US\$460 to US\$2,362, while prices for production of live weight chickens and chicken meat increased by about three-fold. The reasons for the sudden sharp rise in the prices are not clear. Market prices of chicken in Ethiopia are seasonal. Consumer prices generally rise during holidays such as Easter, New Year, and Christmas. Consumer price information obtained in June 2017 shows that the price of a live bird weighing between 1.5 to 1.8 kg was between US\$9–10 while the retail price for frozen whole chicken produced locally was between US\$4–5 per kg (USDA, 2017). The price difference is attributed to the preference of Ethiopian consumers to buying live birds and slaughtering them at home.

Hailemichael et al. (2016) examined poultry marketing in terms of, among others, prices, marketplaces, and supply chain actors. The prices of adult birds (cocks and hens) increased five times between 2006 and 2012: from Birr 58-80 to Birr 290- 400 per bird (US\$ 1.27-1.76 in 2006 and US\$6.38-8.80 in 2012 per bird). This pattern of rising prices indicates the growing demand for poultry, which is an opportunity for poor poultry producers to generate income. Improved breeds fetched higher prices than local ones by 31–200%. This might be due to the need for broodstock rather than for consumption, as local birds are considered to be tastier and best for consumption and ritual sacrifice.

Market places for poultry and eggs included farm gates and other marketplaces located at own or other peasant association outlets or at district, zonal, and regional capitals. Approximately 45% of the birds were sold at district capitals. Farm gate and regional capitals were the market outlets of least importance, making up 3% and <1% of the birds sold, respectively. The types and relative importance of marketplaces for eggs showed similar pattern as for birds. The differences in prices of birds and eggs across these marketplaces should be researched in the future. As discussed previously, market access influences the use of improved technology for village poultry production and thus is a key incentive to boost production by increasing producer's share of benefits rather than that of intermediaries.

The poultry marketing chain in the study areas (Amhara, Tigray, Oromia and Southern region of Ethiopia) involved several actors such as farmers, assemblers, wholesalers, retailers, processors, urban consumers, and cooperatives. Households sold most of their birds (43%) and eggs (36%) directly to urban consumers. Assemblers, retailers and wholesalers together purchased about 50% and 56% of the total birds and eggs sold, respectively. Processors and cooperatives made a very small contribution (<1%) in the supply chain. In general, it can be said that the poultry supply chain is long as at least 50% of the birds and eggs sold flow from producers to consumers indirectly via several intermediaries. Long market chains are characteristic of low market access areas, which adds transaction costs to farmers by involvement of more middlemen. Thus, the contribution of poultry to income is related to market access. This implies that research and development efforts on village poultry cannot have meaningful impact if they do not consider markets.

Value Addition

Dairy and Dairy Products

In Ethiopia, 47.33% of milk produced is processed to butter, local cheeses, and other products (AGP-LMD, 2013b). Milk is traditionally processed into fermented sour whole milk (*ergo*), butter (*kibe*), cottage cheese (*ayib*), buttermilk (*arera*), whey (*agual*), and ghee (*nitir kibe*). Sour milk is churned to produce butter and buttermilk, and the latter is further processed to cottage cheese and whey. Traditional milk processing generally is time consuming and undermines the realization of full value-added milk production (Ayenew et al., 2009). Since about 2005, the number of modern milk processing plants has been increasing; these facilities pasteurize milk and produce yoghurt, cheese, and other products for the domestic market (MOA, 2013). Minten et al. (2020) reported that there are 25 modern dairy processing plants in the country, with a daily processing capacity of 200,000 liters. Only two of those processing plants process ultra-high-temperature

(UHT) dairy products. The average daily processing capacity of the dairy processing plants with UHT is 30,119 liters (Tesfaye et al., 2019). The main challenge with modern processing of milk in Ethiopia is inadequate supply of quality milk, as most of the milk is sold through informal markets. Variations in reported processing capacity may emanate from differences in the criteria for categorizing modern versus traditional processing plants.

Poultry and Eggs

According to FAO (2019b), small-scale farms usually sell live birds and do not have slaughtering facilities. Those who slaughter chickens at their farm use hired labor/butchers and brokers who take the carcasses to their own premises to dress and freeze them for marketing. Slaughtering and processing are carried out manually and 'Halal' slaughter is not practiced. The small-scale farms mostly produce whole plucked and eviscerated carcasses. The medium- and large-scale farms slaughter and process their own birds into plucked, eviscerated and frozen carcasses. However, only a few of these farms go further into producing specialized cuts. The number of farms with automated slaughtering facilities is very small. Broilers, mostly deep-frozen whole chickens from large- and medium-scale farms, are marketed through the farm's own super/mini markets or sold to other super/mini markets or market vendors. Small-scale farmers generally sell poultry to brokers who collect, freeze, and market processed products. Some small-scale farmers sell live birds directly to consumers in local markets. Spent chickens, comprising meat and egg producing females and males, are usually marketed live directly to the local consumers, mostly during festive occasions. However, some farms slaughter, process, and sell spent chickens to market vendors for sale in mini markets and specialized shops equipped with deep freezing facilities.

Challenges

Dairy and Dairy Products

There are various types of challenges in relation to the dairy subsector's development in Ethiopia. Inaccessibility of markets and lack of transport facilities are major bottlenecks. The demand for milk is high in urban areas; however, given the short shelf life of raw milk and the lack, limited availability and/or unaffordable price of transportation, accessibility of the markets is difficult for many rural milk producers. This problem is more pronounced in pastoral areas (Tolera and Abebe, 2007). In Mieso, a district dominated by the pastoral production system, women walk 1 to 12 km (mean of 5.89 km) to reach market places or nearby towns (Hussen et al., 2008). Shortages of adequate market information, lack of cold storage facilities, adulteration of dairy products, and frequent interruptions of electric power also affect the milk market (Geleti et al., 2014a). For instance, 81.5% of households in Gursum and Babille districts of Oromia region reported having market information prior to selling their milk, but the information system was disorganized and inaccurate because the sources of information are traders and friends (Demissie et al., 2014). Additionally, the price of milk is too high for many Ethiopians to frequently buy it (AGP-LMD, 2013b). In some communities, selling fluid milk is a taboo, while marketing of butter, local cheese, and whey is acceptable. In the Ethiopian highlands, there is a general perception of milk as a baby food (AGP-LMD, 2013b). The demand for dairy products decreases during fasting seasons, particularly in the Orthodox Christian dominated highlands (Anteneh et al., 2010; Tegegne et al., 2013). A recent study by Minten et al. (2021) indicated that liquid milk in Ethiopia has a short value chain, which is a sign of the low development of the dairy sector. A challenge limiting development includes inadequate availability of collection centers with chilling tanks for cooperatives or the private sector. In addition, the short value chain has limited spatial outreach, which diminishes access for rural consumers for milk. This underdeveloped liquid milk value chain coupled with the long period of Orthodox Christian fasting affect consumption of milk and increase wastage (Minten et al., 2021).

Meat and Live Animals

The livestock marketing system is limited by various problems, and many of these constraints are common for both domestic and export markets, while some of them are specific to the latter.

- **Long market chain:** The live animal market chain is long. There are four major marketing levels: farm level, primary markets, secondary markets, and tertiary/terminal markets. At the farm level, trade is carried out between producers and local traders. The subsequent markets involve the smaller rural traders, larger traders, butchers, and consumers (Alemayehu, 2011). The presence of these complex marketing channels similarly affects meat and live animal exports. The participating actors are producers, middlemen, livestock trading cooperatives, traders, and meat or live animal exporters (Legese et al., 2008).
- **Lack of market-oriented production:** The absence of a market-oriented production system results in an inconsistent and uneven supply of animals to markets. Large ruminants mostly are sold when they are old, culled, or unproductive, or when cash is required for unforeseen expenses. Producers of beef animals and small ruminants often target their production to cultural or religious festivities (Anteneh et al., 2010; ESGPIP, 2011).
- **Lack of market information and poor market infrastructure:** Producers lack market information. Producers also fail to respond to price changes (Anteneh et al., 2010; Alemayehu, 2011). A study in Tigray region revealed that the information barrier creates a mismatch between the demand from the export abattoirs and the production of suppliers (Asegede et al., 2015). Furthermore, poor market infrastructure limits the efficiency of livestock marketing. In Ethiopia, about 120 market centers are recognized by the government, but these centers are not well organized to provide watering, feeding, resting, and quarantine facilities; the situation is worse in pastoral areas (Anteneh et al., 2010).
- **Informal cross-border trade:** There is informal marketing of beef animals, sheep, goats, and camels at border areas with Somalia, Kenya, Sudan, and Djibouti (Solomon, 2003). The informal marketing, in general, accounts for 80-90% of the country's export of live animals (AGP-LMD, 2013a), and the Ethiopian government losses about US\$300 million per annum from such illegal marketing.
- **Inadequate supply of the required quality live animals:** Inadequate supply of good quality live animals occurs because of illegal cross-border trade, poor livestock market linkages, and lack of infrastructure (Asegede et al., 2015; Ayalew, 2006; Filip, 2006). The informal cross-border trade results in an inadequate supply of the required quality animals for meat processing plants or abattoirs, which reduces potential performance (Alemayehu, 2011).
- **Other factors:** There is poor linkage between abattoirs and animal fattening enterprises (Asegede et al., 2015). About 95% of animals destined for meat or live animal export originate from the lowlands; however, recurring drought and ethnic conflicts in these areas affect the livestock marketing system (Legese et al., 2008). Livestock trade is also limited by lack of or limited transportation. Animals are trekked on foot to market centers and slaughterhouses, which leads to considerable loss of weight and exposure to physical injuries and illness (Anteneh et al., 2010). In addition, infectious diseases, poor veterinary support services, and inadequate application of hazard analysis and critical control points (HACCP) food safety protocols in export markets and abattoirs negatively affect the meat and livestock market, particularly the export market (ESGPIP, 2011).

Poultry and Eggs

The poultry production system is limited by similar challenges as the dairy and meat sectors. General issues for poultry production include poorly functioning farmer organizations, low levels of education among producers, and inadequate availability of water and electricity. The poor coordination of the value chain linkages between input suppliers, service providers, producers, traders and retailers, along with a lack of credit services and risk averse investors, limit production. Another challenge in Ethiopia is the fluctuation in demand for poultry products, with drastic peaks and declines in demand around the Orthodox Christian fasting periods (FAO, 2019b).

The Role of the Government

The Ethiopian Meat and Dairy Industry Development Institute (EMDIDI) under the Ministry of Industry provides support for investors engaged in the production, supply, processing, and marketing of meat and dairy products, as well as monitoring their quality.

The Ethiopian Development bank and other microfinance institutions provide limited financial support for small scale dairy production and processing. However, due to low ceilings of credit and high interest rates, its role in promoting dairy value chain development has been constrained.

In Ethiopia, dairy development is controlled and guided by the Ministry of Agriculture. The ministry provides extension services to smallholder dairy producers to introduce improved livestock technologies, builds the technical capacity of producers, promotes collective action (e.g., formation of cooperatives and unions), and facilitates linkages with other national, regional, and international organizations engaged in dairy research and innovation development (Yilma *et al.*, 2011). Dairy development research endeavors have been oriented towards genetics, husbandry, feed-resource management, animal nutrition, physiology, animal health, dairy processing technology, social economics, and technology transfer. Research has been undertaken on-station and whenever necessary followed by on-farm verifications. The Holetta Agricultural Research Centre (HARC) of the Ethiopian Institute of Agricultural Research (EIAR) serves as a center of excellence for dairy research. The center coordinates all dairy improvement research activities in the federal system as well as in different regional states, including joint venture research activities with agricultural universities and colleges. Both federal and regional research institutions adopt and generate appropriate technologies for dairy development and are also involved in capacity building by organizing and providing trainings. They verify and demonstrate promising technologies on farms with the participation of smallholder farmers.

Federal and regional research systems and universities are responsible for generating technologies and innovations. International organizations like ILRI are also involved in livestock innovations. However, adoption of the technologies is minimal for various reasons. Institutions of higher learning provide long-term trainings on a regular basis to high level agricultural professionals and short-term trainings on request. Universities that provide long-term trainings on dairy related fields include: Haramaya University, Hawassa University, Bahir Dar University, Jimma University, the Veterinary Faculty of Addis Ababa University, and the Asella Model Agricultural Enterprise (AMAE) of Adama University.

There are also 25 Agricultural Technical Educational and Vocational Training (ATEVT) schools operating in different parts of the country that accept students who have completed tenth grade, and they provide a three-year diploma program in one of five disciplines: Animal Science, Animal Health, Agricultural Cooperatives Development, Natural Resources, and Plant Science. All ATEVT schools offer Animal Science, Natural Resources, and Plant Science, while a few others offer Animal Health and Agricultural Cooperatives. The ATEVT curriculum was first introduced in September 2000 by the Ministry of Agriculture and Rural Development (MOARD) in 28 ATEVTs located across the country. In 2001, the number was reduced to 25. The 25 ATEVTs graduated the first Development Agents (DAs) in 2004. By 2008, the colleges had produced nearly 60,000 DAs (12% of them women). The ATEVTs seek to produce mid-level skilled and competent agricultural DAs who will then teach farmers at Farmers Training Centres. There are two categories of ATEVT colleges: federal and regional colleges. There are seven federal colleges (four in the large regions and three in the emerging regions) that report to and are managed by the MOA. The regional colleges are managed by the regional Bureaus of Agriculture (BoA) or the Ministry of Education through the Technical, Educational and Vocational Training (TEVT) Commission (Davis *et al.*, 2010).

There are also several other important players that contribute to the development of the dairy sector. The National Artificial Insemination Centre (NAIC) imports semen of pure exotic breeds and produces semen from selected crossbreed bulls from its Holetta Bull Dam Farm and stores them in liquid nitrogen. The NAIC distributes semen to nine sub-centres (Liquid Nitrogen Plants) located in five regions, namely: Oromia

(Nekemt and Asella), SNNP (Wolayta and Wolkite), Amhara (Bahir Dar and Dessie), Tigray (two sub centers in Mekelle) and Harar. It also provides training on AI service provision to AI technicians as trainees and trainers. The major functions of the sub-centers include supplying AI inputs (semen, liquid nitrogen, and AI equipment), and providing and coordinating AI services in the respective regions. Established in 2008 at Debre Zeit, the Ethiopian Meat and Dairy Technology Institute (EMDTI) provides tailor-made trainings on different aspects of dairy development. Banks and microfinance institutions also play an important role in the dairy development of the country.

Role of Gender and Youth

The Ethiopian government has a gender mainstreaming program where equality of men and women is promoted in all developmental activities in general, and women's participation in the agricultural sector is encouraged at all levels. In livestock related activities, participation of at least 30% women is obligatory. The gender mainstreaming actions of the Ministry of Agriculture also include human resources (staff) gender balance at all levels (MOA, 2012). Both men and women play a significant role along the stages of livestock value chain in Ethiopia (Dabesa, 2020). Women mostly participate in gathering and providing feed to the livestock, watering, take care of the sick and young animals, contributing to cleaning the animal shelter, milking, and contributing to sales of the livestock products. Men are specifically involved in herding, harvesting forage, marketing, and taking livestock to health centers. Livestock ownership between men and women is strongly related to social, cultural, and economic factors. It also depends on the kind of livestock they raise. Notwithstanding the existence of variations across production systems in the relative roles of men and women, women are more involved in dairy, poultry and small ruminant value chains (Gebeyew et al., 2016; Zahra et al., 2014; Abebe and Galmesse, 2011; Kebede et al, 2009; Sintayehu, et al, 2008 cited in Serra et al., 2018). In Ethiopia, women and youth are organized into cooperatives and engaged in feed processing activities for their own use as well as for sale (particularly dairy feed). Some farmers prefer purchasing from the women despite the higher cost, as they believe feed from women is of better quality resulting in more milk (LSIL 2020). Traditionally in Ethiopia, women are believed to be less prone to cheating and feed adulteration. According to the same source, women are also getting involved in forage instead of vegetable production as the former is more profitable.

Dairy Value Chain

As the demand for dairy products has grown steadily and continues to grow, particularly in the urban centers of the country, small-scale dairy production is considered beneficial to women and children as well as men. Milk sales provide regular income that is often accessible to women, while dairy products can be important in diversifying the diets of poor people, in particular children above the age of 12 months and undernourished pregnant women. The noted gender division of tasks in livestock production and management indicate that while roles and responsibilities vary between commodities, locations, and the wealth of the household, it is possible to make some broad generalizations. Women tend to be responsible for activities carried out at or near the home, such as those required for the day-to-day care of animals, and storing, processing, and adding value to livestock products, while men are more often responsible for activities outside the home. One research study found that women are predominantly engaged in the production and marketing of milk and milk products (AGP, 2013). Women in rural areas sell and control income from butter, while women in peri-urban and urban areas sell and control income from milk. The study found that women were predominantly engaged in selling dairy products in informal, local markets and less engaged in formal processing, but they could be involved in formal retailing, although not usually as the owner of a retailing business (AGP, 2013). In another study, fetching and providing water at home was reported to be mainly the responsibility of female members (mother, 51%; daughter, 41.7%), whereas providing water in the field was the major responsibility of the son or any herder (81.2%) (Ulfina, 2019). Most of the respondents (89.6%) reported that construction of livestock housing was carried out by male family members, while barn and dairy house cleaning was mainly accomplished by the female members of the household (Ulfina, 2019). The roles played by different members of households have implications on access to resources. Gender roles assigned to men

and women have impacts on their respective access to resources and the power to decide over benefits of using those resources (Terrill, 2011).

However, there are exceptions and the roles played by men, women, male children, female children, and hired labor cannot be generalized across all groups of dairy keepers. For example, in female-headed households, the head of household may have considerable decision-making power and may consult the adult males of the household less than a husband might consult his wife in a male-headed household. The research report indicated that 15-30% of Ethiopian rural households are headed by women (FAO, 2011). They tend on average to be poorer than those headed by men and may be less food-secure, but as noted by other researchers, the female head of a household may enjoy greater control over resources than married women (FAO, 2010). However, they may also have less access to information from development initiatives that target men, which results in information 'trickling across' to married women. In female-headed households, the household head tends to have full responsibility for sale of dairy products, like milk and butter, and control over the income. This is not only because most female-headed households are solely managed by the women heads, but also in female-headed households including those with the presence of a male partner, decisions over major household resources remain under the sole control of the women heads of the household.

Poultry and Eggs

According to ILRI (2016), female-headed households generated more than twice the income per family member from bird sales than male-headed households. Female-headed households tended to sell a higher portion of their birds. The division of responsibilities among gender categories for poultry selling was also examined. In a majority of the female-headed households, women heads were responsible for a large portion (86%) of the birds that were sold. In male-headed households, 57% and 31% of the birds were, respectively, sold by women (as spouses) and men (as heads). In both household groups, the responsibility for selling of the rest of the birds was shared by other family members, such as female and male children (ILRI, 2016). Regarding bird sales, women controlled more than 90% of the income in female-headed households. In male-headed households, the heads (men) alone and the spouses (women) alone respectively controlled 13% and 30% of the income from bird sales. More than half of the income from bird sales was jointly controlled by the head and spouses in male-headed households. The other household members (children and others) had little role regarding decisions in use of income from poultry. As for birds, selling eggs was largely the responsibility of women in general in both male- and female-headed households. Women sold about 85% of the eggs in both household groups. The contribution of men in male-headed households was only 3% of the eggs sold. Female children sold about 10% and 4% of the eggs, respectively, in female- and male-headed households. Nearly 90% of the income from egg sales was controlled by women in female-headed households. This figure was 60% in male-headed households in which the head and the spouse jointly controlled the income generated from selling eggs. Male and female children had lesser roles (<10%) in that respect.

Role of Producer Groups

Dairy and Dairy Products

Cooperatives play a significant role in ensuring a sustainable supply of raw milk to the dairy industry by coordinating the flow of milk from their members and assisting them by supplying the required dairy farm inputs. Emanu (2009) reported that there are 180 cooperatives engaged in milk production and marketing operating in different parts of the country. However, this number makes only 0.74% of the total number of agricultural and non-agricultural cooperatives (24,167) and 2% of agri-based cooperatives (8,985) in the country. According to the same author, there are a total of four (two each in Amhara and Oromia Regions) milk production and marketing cooperative unions that are formed by cooperatives for better marketing capability and bargaining power. Ada'a Dairy Cooperative is the most successful, while Selale and Asella Dairy Cooperative Unions are currently performing fairly well.

In Ethiopia, almost all milk and milk products are domestically marketed and there is no substantial export market. Indeed, dairy products are imported from abroad, and in the years 2005 to 2009, import values increased from about US\$5.6 to \$10.3 million (Yilma et al., 2011). Imported dairy products were powdered milk, ghee (clarified butter), and different varieties of cheeses. In addition to formal imports, there is minor, predominantly informal, cross-border trade at the Metema-Sudan route, Dire Dawa-Djibouti route, and Jijiga-Togochalle-Somaliland route (AGP-LMD, 2013b).

Poultry and Eggs

There are tens of thousands of primary cooperatives and thousands of cooperative unions in the agricultural sector throughout the country. However, most of these cooperatives and unions are related to crop production and marketing. Insignificant numbers of producer organizations exist in the livestock sector and are almost nonexistent in poultry. A limited number of cooperatives have been organized in feed processing. In the SNNPR, there are six cooperative-established feed mills, and they have started supplying feed mixes for chicken and other livestock species. About the same number operate in the three other major regional states of Oromia, Tigray, and Amhara. The Ethiopian Poultry Producers and Processors Association (EPPPA) was established as part of the Dutch support for the Ethiopian poultry sector. However, EPPPA has not been very active since its establishment and its contribution to the poultry sector has been negligible. The Ethiopian Animal Feed Industries Association is relatively more active, although its roles and impacts on the feed sector are not clearly visible.

Seasonality in the Consumption of Meat

Seasonality in agricultural production and in the supply of agricultural commodities, including ASF, is due to climatic and, most importantly, rainfall patterns. Rainfall in Ethiopia is unimodal in the west and north of the country with rainfall mostly falling between June and September and one main crop harvest (*meber*), while it is bimodal in the east and southeast of the country, giving rise to a second season (*belg*) in those areas. Moreover, rainfall is more reliable in the west and south of the country than in other parts. As the production of feed for livestock is linked to this rainfall pattern, it induces seasonal patterns in the livestock sector. Farmer (2010) shows that seasonality is an important factor in the livelihoods of pastoralist households as rangelands can support fewer animals during the dry season, leading owners to sell livestock during the dry season or migrate to areas with better feed availability, while holding on to livestock during the wet season. For farmers in the highlands, fewer sales of livestock occur during the rainy period as feed is more easily available and cattle are needed for crop cultivation. These factors lead to significant seasonality in ASF prices (Bachewe *et al.* 2017).

Significant seasonality in ASF consumption is also clearly noticed in Ethiopia. One important characteristic of ASF consumption, particularly in Ethiopia, is its link with religion. An estimated 43% of the population is Orthodox Christians (CSA, 2010) and their religion is characterized by important constraints on food intake, especially related to ASF. There are peaks in the consumption of ASF during Ethiopian holidays (Christmas, Timket, Easter, Ethiopian New Year, and the Meskel). These consumption peaks associated with major religious events are preceded by troughs, which are linked with fasting periods that come before these festivals. This is especially so for Christmas and Easter. During the fasting periods of Orthodox Christians – the fasting period for Lent leading-up to Easter lasts up to 56 days and the one before Christmas for about 40 days – no ASF are consumed by most Orthodox Christians. While there are other fasting periods during the year, they are much shorter. This reduction in consumption of ASF also shows up in slaughterhouse data in Addis Ababa. The number of head of cattle and of sheep and goats slaughtered in the “Christian Hall” of the slaughterhouse in the month before Easter typically drops to one-quarter the level of other months (FVI-Idele, 2016). No such seasonality is seen for the “Muslim Hall” during the Muslim major fasting season of Ramadan, and there is no evidence of higher activity at the end of Ramadan or for the Eid festivities (Bachewe, *et al.*, 2017).

Final Remarks

The Livestock Systems Innovation Lab looks forward to another five years of research, innovation, and capacity development in Ethiopia. In our next five years we look forward to researching the priority issues for Phase II:

Livestock Production & Disease Management

The livestock production research should enhance the feed and forage value chains, building on Phase I research and including the learnings from the [EQUIP Feed project](#), funded by the Bill & Melinda Gates Foundation. Priority research topics include:

- Assessing innovative or existing best-bet sustainable and effective crop and residue improvement and conservation techniques that are most likely to scale
- Researching approaches to increase adoption of improved forage varieties.
- Strengthening fodder markets and seed systems.
- Reducing the ASF production costs through climate-smart agricultural practices and decision-support tools that are likely to scale.

Other topics:

- Processing of ASF to increase shelf life and maintain food safety.
- Researching strategies to maintain milk quality and safety during transport, handling, and processing.

Livestock disease management research priorities include:

- Testing different strategies to scale youngstock mortality prevention and mitigation interventions.
- Assessing innovative disease management practices.
- Assessing the economic impact of disease and mortality due to priority diseases identified by the Government of Ethiopia.

Human Health, Food Safety & Diets and Nutrition

In the area of safe livestock production and food safety, research priorities include:

- Improving the understanding and developing risk mitigating measures on the risks of human-livestock cohabitation in smallholder households.
- Integrating existing data into risk assessments that may support deriving appropriate standards for safe levels of aflatoxins in animal feeds, milk, and other dairy products.
- Evaluating the risks relative to benefits of consuming milk containing aflatoxin M1, particularly to children and pregnant and lactating women.

Research priorities around ASF consumption, and dietary diversity and adequacy include:

- Increasing ASF consumption, particularly the impact of increased livestock production or productivity on nutritional outcomes.
- Investigating barriers to ASF consumption, particularly in infants and testing interventions to overcome them.
- Developing and testing social behavior change communication to increase ASF consumption in young children.

Markets & Innovation Translation

Research priorities in this AOI include:

- Researching market opportunities for livestock and ASF supported by supply and demand-side data.
- Researching market performance
- Comparing alternative scaling pathways or design scale-up interventions so that credible analysis of innovation impacts can be conducted at scale.

We are grateful for our Phase I partners and their exciting contributions, and we look forward to building upon our Phase I accomplishments for the next five years.

Livestock Systems Related Projects in Ethiopia

Ongoing

Name of the project	Lead organization	Funding	Duration	Domain	Project areas
Linking Cattle Nutrition to Human Nutrition: A Value Chain Approach to Improving the Production, Handling, and Consumption of Animal Source Foods in Ethiopia *	Kansas State University	USAID through the Feed the Future Innovation Lab for Livestock Systems	2016 - 2020	Beef and dairy value chains	Oromia, Southern, Addis Ababa
Public Private Partnership for Artificial Insemination (PAID): Improving genetics through sustainable partnerships	Land O'Lakes	Bill & Melinda Gates Foundation	2016 - 2021	Dairy	Four Regions in Ethiopia (Amhara, Oromia, Tigray and South)
African Dairy Genetic Gains	ILRI	Bill & Melinda Gates Foundation	2016 - 2021	Dairy	Ethiopia and Tanzania Four Regions in Ethiopia (Amhara, Oromia, Tigray and South)
EQUIP project (FEED and CAGED) *	University of Florida	Bill & Melinda Gates Foundation	2017 - 2022	Health and Feed	Ethiopia and Burkina Faso
Improving Sanitary Capacity and Facilitating Export of Livestock and Livestock Products from Ethiopia	FAO	World Trade Organization / Standards and Trade Development Facility	2018 - 2021	Health and Beef	
Urban food markets in Africa: Incentivizing food safety using a pull-push approach	International Livestock Research Institute (ILRI)	Bill & Melinda Gates Foundation, UKaid from the Foreign Commonwealth & Development Office, A4NH	2018 - 2022	Poultry and vegetables	Harar and Dire Dawa, Ethiopia; Burkina Faso
The Assessment and Management of risk from Non typhoid Salmonella, Diarrheagenic E. coli, and Campylobacter in raw beef and dairy in Ethiopia (TARTARE)	Ohio State University	Bill & Melinda Gates Foundation, UKaid from the UK Department for International Development	2018 - 2022	Beef and dairy	Gondar, Central Ethiopia, Harar/Haramya
Ensuring the Safety and Quality of Milk and Dairy Products Across the Dairy Value Chain in Ethiopia, Ethiopia	Addis Ababa University, Kansas State University	Bill & Melinda Gates Foundation, UK aid from the UK Department for International Development	2018 - 2022	Dairy	Selected districts of four regional states in Ethiopia: Oromia, Southern nations and

Name of the project	Lead organization	Funding	Duration	Domain	Project areas
					nationalities, Tigray and Amhara
Foodborne disease epidemiology, surveillance, and control in African low-middle-income countries (LMIC)	Technical University of Denmark	Bill & Melinda Gates Foundation, UKaid from the UK Department for International Development	2018 - 2022	Food Safety	Ethiopia and other African countries
Building Rural Income through Inclusive Dairy Growth in Ethiopia (BRIDGE)	Wageningen University and Research (WUR) and SNV	Embassy of the Kingdom of the Netherlands	2018 - 2023	Dairy	Amhara, Oromia, Tigray and Southern regions of Ethiopia
Livestock and Fisheries Sector Development project	MOA	World Bank	2018 - 2024	All livestock domains including fisheries	Six regions of Ethiopia (Amhara, Oromia, Tigray, Southern, Benshangul Gumuz and Gambella)
Precision Agriculture for Development (PAD)	PAD and ATA	Bill & Melinda Gates Foundation	2020 - 2023?	Livestock Extension	All parts of Ethiopia
Silvopastoralism and welfare of animals in Borana	ILRI	Switzerland Government	2021	Dairy, Feed, Animal Health	Borana pastoral areas
Feed-to-Farm Investigation of Mycotoxin Contamination of Feed and Milk in Ethiopia *	Kansas State University	USAID through the Feed the Future Innovation Lab for Livestock Systems	2019 - 2021	Feed safety	All parts of Ethiopia
Global Burden of Animal Diseases	ILRI	Bill & Melinda Gates Foundation	2021 - 2022	Animal health	
Health of Ethiopian Animals for Rural Development	ILRI	European Union (EU)	2019 - 2022	Animal health	Amhara, Oromia and Somalia regions
Epidemiology and control of <i>Peste des Petits ruminants</i> in East and West Africa	ILRI	EU through International Fund for Agricultural Development (IFAD)	2019 - 2022	Animal health	Burkina Faso Ethiopia Kenya Mali Senegal Tanzania
One Health for Humans, Environment, Animals and Livelihoods (HEAL)	ILRI	EU	2019 - 2023	One Health	Ethiopia, Kenya & Somalia

* These are projects that were funded during Phase I of the Feed the Future Innovation Lab for Livestock Systems

Recently Completed

Name of the project	Lead Institution	Donor	Duration	Domain	Project areas
African Chicken Genetic Gains	ILRI	Bill & Melinda Gates Foundation	2014 - 2019	Poultry	Ethiopia, Tanzania & Nigeria
Addressing Young Stock Mortality in Smallholder Farms and Pastoral Herds of Ethiopia *	University of California - Davis	USAID through the Feed the Future Innovation Lab for Livestock Systems	2016 - 2020	Animal health	Amhara, Oromia, Afar, Southern regions of Ethiopia
The Effect of Passive Surveillance Training on Animal Health Parameters, Northern Ethiopia *	University of Georgia	USAID through the Feed the Future Innovation Lab for Livestock Systems	2016 - 2020	Animal health	Tigray Region
Agriculture to Nutrition (ATONU)	ILRI	Bill & Melinda Gates Foundation	2017 - 2019	Poultry and human nutrition	Amhara, Oromia, Southern, Tigray regions
Improving the Evidence and Policies for Better Performing Livestock Systems in Ethiopia *	International Food Policy Research Institute (IFPRI)	USAID through the Feed the Future Innovation Lab for Livestock Systems	2017 - 2020	Dairy, ASF marketing	All over the country
Improving handling practices and microbiological safety of milk and milk products in Borana pastoral communities, Ethiopia *	Addis Ababa University and ILRI	USAID through the Feed the Future Innovation Lab for Livestock Systems	2018 - 2020	Dairy	Borana Pastoral area, Ethiopia
Mycotoxin Prevalence and Mitigation Measures in Ethiopia *	Kansas State University	USAID through the Feed the Future Innovation Lab for Livestock Systems	2019 - 2020	Feed safety	Amhara, Oromia, Southern, Tigray regions
Application of Integrated Decision Support Systems to Improve Livestock Systems in Ethiopia: Research and Capacity Development *	Texas A&M University	USAID through the Feed the Future Innovation Lab for Livestock Systems	2019 - 2020	Modeling livestock systems	All parts of Ethiopia

Name of the project	Lead Institution	Donor	Duration	Domain	Project areas
Modeling Livestock System Dynamics and Economywide Policy Impacts in Ethiopia *	IFPRI	USAID through the Feed the Future Innovation Lab for Livestock Systems	2019 - 2020	Modeling livestock systems	Not area specific

* These are projects that were funded during Phase I of the Feed the Future Livestock Systems Innovation Lab

Annex Table 1. Broiler Production Capacity of Major Commercial Poultry Farms in Ethiopia

Farm Name	Boiler Breeder Flock Size	Batch	Net Broiler Breeders (8%)	DOCs (Commercial)	Total After Net Mortality of DOCs 5%
Alema Farms	5,000	4	4,600	656,880	624,036
ELFORA	7,500	2	6,900	985,320	936,054
Hage Farm	3,000	3	2,760	394,128	374,422
SW Farm	4,000	3	3,680	525,504	499,229
Bisrate Gebriel Poultry Farm	4,000	1	3,680	525,504	499,229
Elere Farm	6,000	1	5,520	788,256	748,843
Chico Meat	5,000	1	4,600	656,880	624,036
TOTAL	71,000			4,532,472	4,305,849

Source: ENTAG (2020)

Annex Table 2. Estimated Egg Production from Commercial Farms

Farm Name	Layer Breeders	Dual	Total Breeders	Total Layers	Eggs Per Annum	Total
EthioChicken		120,000	120,000	5,540,400	120	664,848,000
EthioChicken	30,000		30,000	1,385,100	120	166,212,000
ema Farms	7,500		7,500	692,550	246	170,367,300
Gerado Farms	10,000		10,000	923,400	246	227,156,400
Ene Ali Yimer	3,000		3,000	277,020	246	68,146,920
Golden Poultry Farm	4,500		4,500	415,530	246	102,220,380
Hawassa Farm	10,000		10,000	923,400	246	227,156,400
Hawassa Farm		20,000	20,000	923,400	120	110,808,000
Bedele Farm	3,500		3,500	323,190	246	79,504,740
EIAR	3,800		3,800	350,892	246	86,319,432
EIAR		1,700	1,700	78,489	120	9,418,680
Elere Farm	5,000		5,000	461,700	246	113,578,200
TOTAL	87,300	141,700	219,000	12,295,071		1,790,214,048
Commercial Layers						
Farm Name	Flock Size	Mortality From Flock (10%)	Production Days	Number of Eggs	Production Rate	Total Number of Eggs
ELFORA	86,400	77,760	365	28,382,400	80%	22,705,920
Maranatha Poultry Farm	40,000	36,000	365	13,140,000	80%	10,512,000
Debre Holland Poultry Farm	40,000	36,000	365	13,140,000	80%	10,512,000
					TOTAL	43,729,920
Total egg production in quantity						1,833,943,968
Egg weight in kg						0 .04
Total egg production in kg						73,357,759
Total population						100,000,000
Per capita egg consumption in no. of eggs						18 .339
Per capita egg consumption in kg						0.734

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