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Comprehensive Livestock Driven Typology for Food and Nutrition Security in Africa: Case Study from Ethiopia

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Contents

Abstract

Despite the sustained economic growth and improvements in agricultural productivity the country has achieved over the years, food and nutrition insecurity remains a serious challenge in Ethiopia. The livestock subsector, which is a major contributor to the agricultural sector and the country's overall economy, could play a critical role in food systems and in improving nutrition. This paper employs a spatial typology to identify interventions that could help increase the production and consumption of livestock-based foods. Using data for the four dimensions of the comprehensive food and nutrition security framework, we estimate efficiency and average performance in terms of livestock production, access and utilization. A stochastic frontier approach is employed to estimate the production potential for the livestock sector. The results reveal that distance to the nearest road, household size, and the gender of household heads all reduce inefficiency in livestock production. The findings also indicate that low livestock potential is correlated with a low level of food and nutrition security and that Ethiopia has very low per capita consumption of livestock production. Low livestock potential is attributed to a lack of feed, water and veterinary services. Therefore, policy interventions to enhance livestock production and improve livestock production efficiency could include putting more resources into veterinary services and the provision of subsidies for animal feed, as well as the introduction of policies geared towards increasing water supply, improving access to equipment for producers, and facilitating their access to credit and quality inputs. Knowledge of nutrition at the household level could also be improved through awareness-raising communications, including making agriculture extension services more nutrition sensitive.

Comprehensive Livestock Driven Typology for Food and Nutrition Security in Africa: Case Study from Ethiopia

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1. INTRODUCTION

Africa south of the Sahara is continuing to experience economic growth, with growth projected to remain at 3.2 percent in 2019 and rise to 3.6 percent in 2020 (IMF 2019). However, the continent continues to be the most food insecure part of the world. As pointed out by FAO et al. (2020), the prevalence of undernourishment has been rising in the region. The deterioration has slowed, but there are still about 256 million hungry people in Africa. Although many African countries are making progress towards reducing malnutrition, progress is too slow to meet six key nutrition targets of the Sustainable Development Goals (SDGs). As a result, the continent is not on track to eliminate hunger by 2030. Moreover, "hidden hunger" is still widespread; about half of all children under five suffer from micronutrient deficiency, especially in vitamin A, zinc, and iron, which limits their development, health, and future working capacity. The effects of micronutrient deficiency can be irreversible. For example, without iodine, children are susceptible to brain damage. Nearly 48 percent of Africa's population relies on cereals and root staples that lack vital micronutrients (Wawa, 2019). Millions have no access to or cannot afford foods such as vegetables, fruit, and animal products that are rich in micronutrients.

As pointed by Fan (2018), livestock plays a critical role in food systems as an important source of income and as a labor-saving and productive asset. It also contributes to nutrition, as consumption of a diverse array of animal-sourced foods (ASF) is strongly associated with child growth. The downsides of animal production and consumption are the environmental footprint (Steinfeld et al. 2006), the overconsumption of ASF in middle- to high-income countries and, as demonstrated by Poore and Nemecek (2018), the contribution to climate change (Steinfeld et al. 2006; Gerber et al. 2013).

In many African countries, population growth, higher incomes, and urbanization – with its associated dietary changes – have increased the demand for livestock products (Thornton 2010; Delgado 2005). Higher demand for livestock products creates new opportunities for public and private investments along livestock value chains. To guide the selection and design of appropriate interventions, in this paper we propose a typology based on a comprehensive food and nutrition security (FNS) framework for livestock in Ethiopia which includes four dimensions or pillars: potential, availability, access, and utilization. Using data for each of the four dimensions, we estimate efficiency and average performance in terms of livestock production, access and utilization. Our methodology builds on previous studies by Marivoet et al. (2019), Torero (2014), and Yu et al. (2010). As discussed in the work of Marivoet et al. (2019), for developing countries the typology proposed in this paper is preferable to household-based targeting as it is more cost-effective. In addition, location-based targeting is appropriate since it is beyond the control of an individual household. Whereas nutritional status will be used to set priority levels, the measure of efficiency is used to guide locations where appropriate investments in livestock will produce greater benefits in terms of food security, employment, and poverty alleviation. To assess production potential for the livestock sector, we use the stochastic frontier framework (SFF) which allows for the estimation of both livestock efficiency and its drivers. As pointed out by Marivoet et al. (2019), the resulting typology is conceptually sound, operationally flexible and less data intensive.

This paper continues as follows. In Section 2, we discuss the state of food and nutrition security in Ethiopia and the role of livestock in achieving food and nutrition security in the country. The methodology employed for the study is described briefly in Section 3. In Section 4 we present a descriptive analysis of data and variables involved in the typology. The results of the typology are presented and discussed in Section 5. Lastly in Section 6, we discuss the policy implications of the typology.

2. BACKGROUND OF THE STUDY

2.1 State of food and nutrition security

Over the past two decades the Ethiopian government has implemented a comprehensive economic reform program that has resulted in remarkable economic performance. The country implemented its first five-year Growth and Transformation Plan (GTP I) from 2010 to 2015 and a second plan (GTP II) from 2016 to 2020. The Ethiopian economy grew 10.1 percent during the GTP I period. Under GTP II, the economy recorded an average annual growth rate of 8.1 percent (FDRE 2020). This sustained period of economic growth has resulted in higher employment, increased household incomes, and a significant reduction in poverty. Average annual per capita income increased from US$ 342 in 2010 to US$ 483 by 2015 and improved continuously to reach US$ 623 in 2020 (WDI 2021).

The proportion of the population living in poverty declined from 29.6 percent in 2010 to 23.5 percent in 2015. Since most of the population lives in rural areas and poverty is mainly a rural phenomenon, agricultural growth constitutes a major poverty reduction strategy in the country. Even though agricultural productivity is generally low, the productivity of major cereals, pulses and oilseeds improved from 2.4 tons per hectare in 2014–2015 to 2.5 tons per hectare in 2016–2017 (FDRE 2018). Despite the robust and sustained economic growth and improvements in agricultural productivity achieved in Ethiopia over the years, a substantial proportion of the population continues to live in abject poverty and population growth continues to exacerbate the already serious challenge of food and nutrition security in the country.

Food and nutrition insecurity is addressed by the Productive Safety Net Program (PSNP), which is the country's rural safety net for food insecure households, and is implemented in eight regions (Afar, Amhara, Dire Dawa, Harari, Oromiya, Southern Nations, Nationalities and Peoples (SNNP), Somali and Tigray). The program supports close to eight million households suffering from chronic and transitory food insecurity through cash and/or food transfers.

Trends in household dietary diversity based on the household dietary diversity score (HDDS) – which ranges between 0 and 12 – reveals that household diets in both the highland and lowland regions are monotonous (Berhane et al. 2018). Consumption of fruit and ASF (meat, eggs and dairy) is generally limited in the highland localities, with diets generally dominated by cereals, pulses, vegetables and oils. Diets in the lowland localities are dominated by cereals, dairy products and vegetables, with limited consumption of fruit, eggs, meat products and pulses. Dietary diversity in the highland regions improved marginally between 2016 and 2018 and gender and regional differences in dietary diversity have been found to be negligible (Berhane et al. 2018). Similar trends are observed in dietary diversity in the lowland regions.

Ethiopia has witnessed encouraging progress in reducing food and nutrition insecurity. However, child malnutrition (stunting, wasting and underweight) and micronutrient deficiencies remain high, albeit with improving trends. The 2016 EDHS (Ethiopian Demographic Health Survey) estimated the national prevalence of stunting among children under the age of five at 38 percent, the prevalence of underweight at 24 percent and wasting at 10 percent. The survey result shows the presence of marked differences among the regions in all of the three measures of child malnutrition. For example, the prevalence of child stunting is estimated as being as high as 46.3 percent in the Amhara region while it was 23.5 percent in the Somali region. The prevalence was lowest in the capital city Addis Ababa, at 14.6 percent. Under-five child mortality and infant mortality rates are estimated at 67 deaths per 1000 live births and 48 deaths per 1000 live births, respectively (FDRE 2016). Some progress towards achieving better child health and nutrition has been observed in recent years. Recent data show that 37 percent of children under five are stunted, 7 percent are wasted, and 21 percent of all children are underweight (FDRE 2019). According to the 2019 EDHS, the prevalence of stunting has decreased considerably, from 51 percent in 2005 to 37 percent in 2019, while the prevalence of wasting decreased from 12 percent to 7 percent over the same period. The percentage of underweight children has consistently decreased from 33 percent to 21 percent during the period under reference (2005–2019) (FDRE 2019).

2.2 Role of livestock in achieving food and nutrition security

Ethiopia is endowed with vast livestock resources, and the livestock subsector has quite a prominent role within the agricultural sector. The country's livestock herd is one of the largest in Africa and has the potential to contribute significantly

to economic growth and poverty reduction. Ethiopia's agro–ecological diversity influences the production and productivity of its livestock resources. The Ministry of Agriculture (MOA) officially identifies three major production zones for the country: lowland grazing (LG), including both pastoral and agro-pastoral systems, highland crop-livestock mixed rainfall deficient (MRD), and highland crop-livestock mixed rainfall sufficient (MRS) (LSA 2017). The livestock population of Ethiopia, which consists of 55.2 million cattle, 29 million sheep and the same number of goats, 4.5 million camels and close to 50 million poultry (Shapiro et al. 2017) is the largest in Africa and the fifth largest in the world, and contributes close to 20 percent of the country's GDP (World Bank 2017). According to the Ethiopian 2019–2020 agricultural sample survey, the livestock population of the country included about 65 million cattle, 40 million sheep, 51 million goats, 8 million camels, and 49 million chickens. Table 1 shows the distribution of Ethiopia's livestock resources across livestock production systems. The specialized livestock production systems, which have unique modern production features and a commercial orientation, are spread across the production systems in the country and include cattle and chicken.

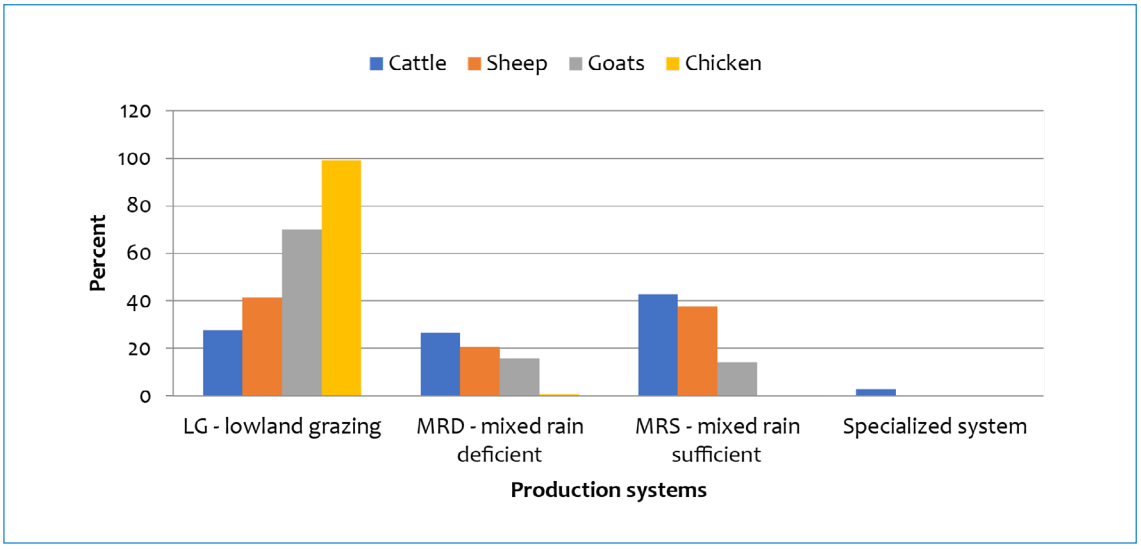
Table 1: Distribution of the national livestock herd over production systems (2013) in Ethiopia (millions)

Species	Low Grazing (LG)	Maximum Rainfall Deficiency (MRD)	Maximum Rainfall Sufficient (MRS)	Specialized production	Total
Cattle	14.80	23.52	1.60	55.21	14.80
Sheep	6.05	11.10	NA	29.36	6.05
Goats	4.58	4.12	NA	28.95	4.58
Camels	NA	NA	NA	4.50	NA
Chicken	0.41	NA	NA	47.64	0.41
Beehives	NA	NA	NA	4.99	NA
Equine	NA	NA	NA	7.17	NA

Source: LSA (2017)

Figure 1 presents the distribution of livestock by major production systems; 70 percent of the country's cattle population is located in the mixed crop livestock system that comprises moisture sufficient (MRS) and moisture deficient (MRD) production zones.

Figure 1: Distribution of livestock herds by major production system in 2013 (percent) in Ethiopia



Source: LSA (2017)

As shown in Figure 1, the MRS production zone tends to support more cattle (43 percent) compared to the MRD zone (27 percent). The lowland grazing system (LG) accounts for about 28 percent of the cattle population while the specialized production system has a negligible share (3 percent) of the total cattle population in the country. The sheep population is distributed in the three major production zones with 42, 38 and 21 percent of the population found in the LG, MRS and MRD zones, respectively. Goats show a marked presence (70 percent) in the LG system and the remaining 30 percent of the goat population is distributed in the MRD (16 percent) and MRS (14 percent) systems. The LG production zone is home to almost the entire chicken (99 percent) and camel population.

In terms of production, livestock resources provided 1,080,767 tons of meat and about 5.2 billion liters of milk from cattle, goats and camels in 2013. The production level of cow's milk was roughly 3.73 billion liters (Table 2).

Table 2: Meat and milk production by production system (2013) in Ethiopia (millions)

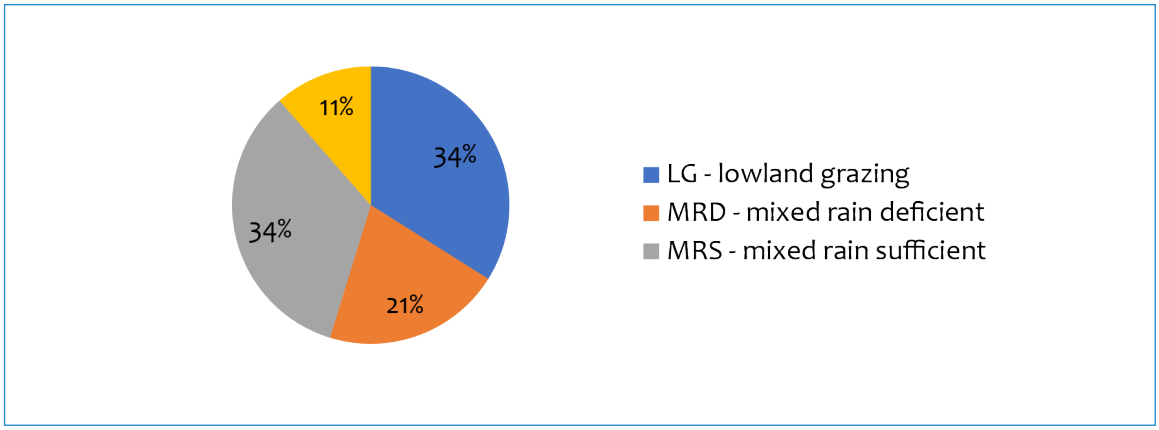
Agro-ecological zone	Total meat (tons)	Total milk ('000 liters)	Cow milk ('000 liters)
Lowland Grazing (LG)	**0.37**	**1.97**	**0.52**
Mixed Rainfall Deficiency (MRD)	**0.23**	**0.83**	**0.83**
Mixed Rainfall Sufficient (MRS)	**0.37**	1.88	1.88
Specialized	**0.12**	**0.50**	**0.50**
TOTAL	**1.08**	**5.18**	**3.73**

Source: LSA (2017)

The distribution of meat and milk production by major production systems is depicted in Figures 2 to 4. The LG and MRS production zones generate much of the meat produced in the country, accounting for 34 percent each. This is followed by the MRD zone, contributing 21 percent of total meat production. The specialized production system, which accounts for a small proportion of the cattle population, contributes 11 percent of total meat production in the country. The LG production system leads in total milk production (38 percent) closely followed by the MRS zone which accounts for 36 percent. The highest share of milk production in the LG zone is mainly due to the contribution of camel milk, which is produced only in this zone. The MRD and specialized production systems account for 16 and 10 percent of total milk production, respectively. When it comes to cow's milk, much of the output comes from the highland livestock production systems. The MRS production system accounts for more than half (51 percent) of total cow's milk production, with the MRD production zone trailing behind at 22 percent. The LG zone, which has a slightly higher cattle population compared to the MRD zone, accounts for only 14 percent of total cow milk production. On the other hand, the specialized production system accounts for 13 percent of cow milk production based on only three percent of the total cattle population in the country. The productivity of the specialized system is thus very high compared to that of the other production systems.

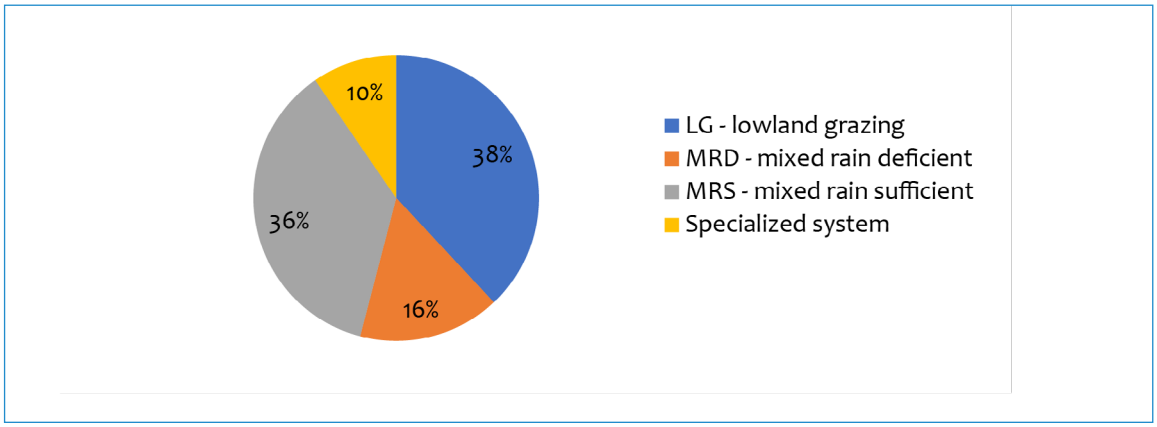
The demand for meat and milk in the country is essentially met from domestic production. However, the demand for these products is expected to rise in line with the rapidly growing population and an increase in per capita income driven by ongoing rapid economic growth. The projected increase of the population to 127 million people, coupled with rising per capita income, is expected to result in a deficit of about 1.3 million tons of meat (53 percent) and 3,185 million liters of milk (29 percent) in 2028 (LSA 2017). Given that the demand for milk is generally greater in urban settings, this deficit is expected to be much higher in urban areas than in rural ones.

Figure 2: Distribution of meat production across production systems (2017) in Ethiopia



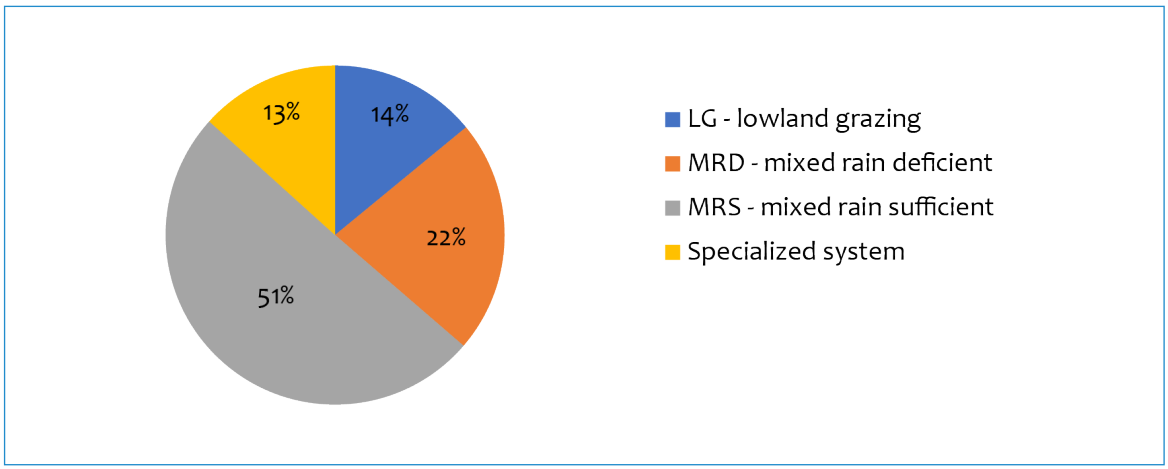
Source: Based on data from LSA (2017)

Figure 3: Distribution of milk production by production systems (2017) in Ethiopia



Source: Based on data from LSA (2017)

Figure 4: Distribution of cow's milk by production systems



Source: Based on data from LSA (2017)

Meeting the projected gap in demand for meat and milk will require substantial investment in the sector. Tables 3 and 4 present projections of the production and consumption of meat and milk over a period of 15 years (2013–2028) without and with additional investment, respectively. A methodological note on the estimation of current and projected production and consumption of livestock products, depicted in Tables 3 and 4, as well as data on investment interventions and required investment costs are given in Annex 1. Over a period of 15 years (2013–2028), the consumption of red meat (beef, sheep, goat and camel meat) is projected to grow by about 283

percent from 731,400 tons in 2013 to 2.8 million tons in 2028 (Table 3). Production of red meat, on the other hand, increases by just 38.3 percent from 1.08 million tons to 1.49 million tons. Thus, by 2028 there will be a gap of about 1.3 million tons between the production and consumption of red meat in the country, with domestic production able to cover only 53.3 percent of domestic demand. A similar pattern is observed in the projected production and consumption of chicken meat and milk. The consumption of chicken meat is projected to rise by about 64.6 percent from 47.7 thousand tons in 2013 to 78.5 thousand tons in 2028 while consumption is expected to increase by about 155.3 percent from 43.8 thousand tons to 111.8 thousand tons during the same period. This implies a 33.3 thousand ton gap between the production and consumption of chicken meat, with the country able to supply only 70 percent of demand through domestic production in 2028. With the production of milk projected to increase by 49.9 percent from 5,182.4 million liters in 2013 to 7,767.6 million liters in the face of a 127.1 percent increase in consumption (from 4822.7 million liters in 2013 to 10,952.7 million tons in 2028), domestic production of milk is expected to cover 71 percent of demand in 2028. Overall, the 15-year projection of meat and milk production and consumption reveals significant production gaps for these products under a 'business–as–usual' scenario, i.e. without any intervention in the sectors.

Closing the production gap in animal products expected in 2028 requires substantial investment in the sector, particularly for cattle rearing in all zones, sheep rearing in MRS and MRD, and goat rearing in LG to be profitable. Investment priorities need to focus on veterinary services, improvement in animal genetics and productivity, and the importation of exotic breeds to crossbreed with local animals (LSA 2017).

Table 3: Current and projected production and consumption of livestock products without interventions (thousand tons or million liters) (2013 to 2028) for Ethiopia

Livestock Product	Production ('000 tons & million liters)		Consumption ('000 tons & million liters)		% Change (2013 to 2028)		Production as a % of consumption
	2013	2028	2013	2028	Production	Consumption	2028
Beef	810.7	1,073.2	554.1	2,301.50	32.4%	315.36%	47
Mutton	102.2	174.7	63.2	182.6	70.9%	188.92%	96
Goat meat	94,230	168.7	60.7	182.6	79.0%	200.82%	92
Camel meat	73.6	76.9	53.4	134.2	4.5%	151.31%	57
Red meat	1,080	1,493.6	731.4	2,800.90	38.3%	282.95%	53
Chicken meat	47.7	78.5	43.8	111.8	64.6%	155.25%	70
All meat	**1,128.50**	**1,572.1**	**775.2**	**2,912.70**	**39.3%**	**275.74%**	**54**
All milk	**5,182.40**	**7,767.6**	**4,822.70**	**10,952.70**	**49.9%**	**127.11%**	**71**

Source: (LSA 2017)

Table 4 shows projected meat production for 2028 with combined investments and poultry improvement interventions (LSA 2017). Investment interventions would enhance red meat production by 81 percent to 2,614,000 tons and chicken meat by 19 percent to 619,000 tons in 2028. But even with the implementation of the required investment interventions, a red meat deficit of seven percent, or 187,000 tons, is expected in the year 2028 (Table 4). Investment in poultry improvement interventions is expected to generate a surplus of 507,000 tons, which amounts to a staggering 453 percent of surplus production. With successful investment interventions, a production surplus of 320,000 tons all meat, or 11 percent of consumption, is expected in 2028. In the case of cow's milk, if the proposed investment interventions are successfully put in place, the LSA results project a 20 percent surplus of about two billion liters of milk by 2028. According to the LSA results the future projected surplus in milk will be realized through investment in better genetics, feed, and health services to improve both traditional dairy farms and commercial-scale specialized dairy production (SDP) units.

Table 4: Projected meat production-consumption balance with combined investment interventions in 2028 and poultry improvement interventions in Ethiopia

Livestock Product	Production ('000 tons)		Consumption ('000 tons)		Production – Consumption balance (+/-) ('000 tons)	Production deficit (-)/ surplus (+) as a % of consumption (%)
	('000 tons)	(%)	('000 tons)	(%)		
Beef	2,081	64	2302	7	-221	-10
Mutton	216	7	183	6	33	18
Goat meat	218	7	183	6	35	19
Camel meat	100	3	134	5	-34	-25
All red meat	2,614	81	2801	96	-187	-7
Chicken meat	619	19	112	4	507	453
All meat	3,233	100	2913	100	320	11

Source: LSA (2017)

The livestock subsector is a major contributor to the agricultural sector and to the overall economy of the country. The LSA estimates the direct contribution of livestock to GDP in 2013 at 150.7 billion Ethiopian birr (ETB) (US$ 7.8 billion)[1], which amounts to 17 percent of GDP and 39 percent of agricultural GDP (LSA 2017). The GDP contribution of livestock increases substantially when the indirect contributions of the subsector are taken into account. Adding up the value of processing and marketing, which stands at ETB 35.6 billion, raises the contribution of livestock to about 21 percent of national GDP and 49 percent of agricultural GDP. Furthermore, taking into account the indirect contribution of livestock – including organic fertilizer and traction power, which is valued at ETB 37.8 billion – further raises the contribution of the subsector to about 25.3 percent of national GDP (LSA 2017).

Table 5 summarizes the composition of the direct value of the livestock subsector added at farm/herd level. Milk contributes relatively the highest value (34 percent) to the livestock sector. Other livestock products that considerably contribute to the value added by the subsector are beef (20 percent), organic matter (18 percent) and draft power (14 percent). The value addition from hides and skins, eggs, poultry meat and camel meat remains insignificant (Table 5).

Table 5: Composition of the subsector direct added value at the farm/herd level 2013

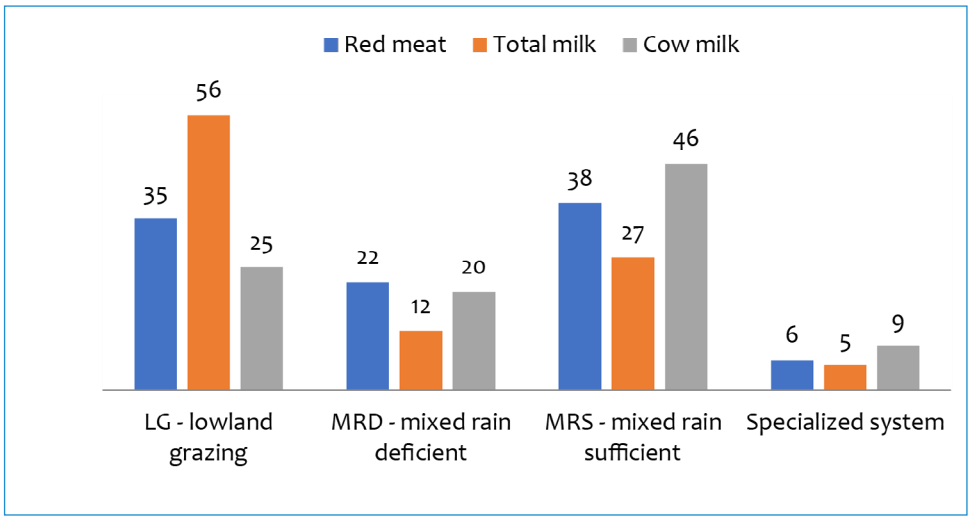
Commodity	Value (ETB, millions)	Share
Beef	30,688	20%
Small ruminant meat	11,913	8%
Camel meat	3,226	2%
Poultry meat	3,592	2%
Milk	51,352	34%
Eggs	307	0.2%
Hides and skins	22	0.1%
Organic matter	27,866	18%
Draft	21,770	14%
TOTAL	150,736	100%

Source: LSA (2017)

1 USD 1 = ETB 19.35 (as of December 1 2013) (Shapiro et al. 2017).

Figure 5 shows the contribution of red meat and milk to GDP in the three major agro-ecological zones and the specialized production system. Milk provides the most value added in the LG production zone, underlining that this zone is essentially a dairy system. With milk accounting for the most value added in the LG system, together with the substantial contribution of red meat to GDP (35 percent), there is a clear need to consider the role of these pastoral areas in national development plans. Cow's milk and red meat provide the highest value addition to GDP under the MRS production system, at 46 percent and 38 percent respectively. The value added contribution of cow's milk and red meat in the MRD system stands at 20 and 22 percent, respectively. Figure 5 shows that the contribution of the specialized system (urban dairy in the case of milk, and feedlots in the case of red meat) is still incipient.

Figure 5: Contribution of red meat, total milk and cow's milk to subsector GDP by major production system (percent) in Ethiopia



Source: Computed based on data from LSA (2017)

The livestock sector is an important source of employment. About 85 percent of Ethiopia's population live in rural areas and livestock supports the livelihoods of about 80 percent of rural people (ILRI 2011, cited in Shapiro et al. 2017)). Since poverty is mainly a rural phenomenon, the livestock sector can be a major contributor to poverty reduction by improving the livelihoods of rural people. In addition to employment, livestock provides nutritious food, cash income for everyday or emergency expenses and social obligations, near liquid assets, a store of wealth for savings in the absence of formal financial institutions, manure for crop production and soil fertility, and transport (ILRI 2011). Livestock development also has the potential to positively affect urban consumers through lower animal product prices.

The role of livestock in the national economy in terms of contribution to export earnings is limited. Ethiopia mainly exports meat, meat products and live animals. Table 6 shows the contribution of the livestock subsector to export earnings. The value of exports of meat and meat products increased from a mere US$ 20.9 million in 2007–2008 to US$ 107.7 million in 2017–2018 and averaged at US$ 69.28 million over the 11-year period. The limited foreign exchange contribution of the product is apparent from its small share in total export earnings, which ranged from 1.4 percent in 2007–2008 to 3.6 percent in 2017–2018. Similarly, exports of live animals are quite low, albeit slightly higher than those of meat and meat products. Likewise, the export of leather and leather products amounted to an annual average value of US$ 108 million during the period under review, with an export share of less than 5 percent in most of the cases. The major constraints contributing to the low export performance of the livestock sector include the low supply of quality animals, lack of quality and supply of raw hides and skins, the illegal live animal trade, and limited access to finance (Alemayehu and Ayalew 2013). Major destinations for Ethiopia's livestock exports include Saudi Arabia, Qatar, Kuwait, and the United Arab Emirates (for meat and live animals) and China, the UK, Italy, Thailand, and India for leather and leather products.

Table 6: Livestock contribution to export earnings (2007/08 – 2017/18)

Year	Leather and leather products		Meat & meat products		Live animals	
	Value (Million USD)	Share of total export (%)	Value (Million USD)	Share of total export (%)	Value (Million USD)	Share of total export (%)
2007/08	99.2	6.8	20.9	1.4	40.9	2.8
2008/09	75.3	5.2	26.6	1.8	52.7	3.6
2009/10	56.4	2.8	34	1.7	90.7	4.5
2010/11	103.8	3.8	63.3	2.3	147.9	5.4
2011/12	109.9	3.5	78.8	2.5	207.1	6.6
2012/13	121.1	3.9	74.3	2.4	166.4	5.3
2013/14	129.8	3.9	74.6	2.3	186.68	5.7
2014/15	131.6	4.4	92.8	3.1	148.51	4.9
2015/16	115.3	4	96.4	3.4	147.8	5.2
2016/17	114	3.9	98.7	3.4	67.6	2.3
2017/18	132.4	4.7	101.7	3.6	61.2	2.2

Source: National Bank of Ethiopia, Annual Report 2010/11 – 2017/18.

As a major source of protein, the contribution of livestock in reducing malnutrition and stunting is highly significant. However, the contribution of livestock to nutrition has so far been limited as the dietary diversity of the population is very low (Goshu et al. 2013). In 2013, the per capita consumption of red meat in Ethiopia was 8.5 kg (Table 7). The per capita consumption of chicken meat and egg was quite low at 0.5 kg and 1.8 kg, respectively, in the same year. Milk consumption was 56.2 kg per capita in 2013, with cow's milk accounting for most of it (43.3 kg per capita). Projections to 2028 indicate significant improvements in the consumption of livestock products in the country.

The per capita consumption of red meat, chicken meat and eggs is expected to have increased by 177.6, 80 and 355.6 percent, respectively, in 2028 relative to 2013. Per capita consumption of all meat types increases substantially during the reference period though beef should see the greatest increase (200 percent). Per capita consumption of all milk types by 2028 should rise by 65 percent relative to 2013. With such a substantial expansion in the consumption of livestock products expected in the future, the contribution of the livestock sector in improving nutrition and curbing the adverse effects of malnutrition will increase significantly over the years.

Table 7: Per capita consumption of livestock products in 2013 and 2028 for Ethiopia

Livestock product	Annual per capita consumption (kg/year)		Growth in annual per capita consumption (2013–2028) (%)
	2013	2028	
Beef	6.5	19.5	200
Mutton	0.7	1.5	114.3
Goat meat	0.6	1.5	114.3
Camel meat	6.5	1.1	83.3
Red meat	8.5	23.6	177.6
Chicken meat	0.5	0.9	80
All meat	9	24.5	172.2
Egg	1.8	8.2	355.6
Cow milk	43.3	71.5	65.1
Camel milk	11.2	18.5	65.2
Goat milk	1.7	2.8	64.7
All milk	56.2	92.8	65.1

Source: LSA (2017)

The country's enormous potential for livestock production is constrained by several factors including inadequate feed resources, widespread animal disease with limited animal health services, low genetic potential of the indigenous national herd, and poor marketing and processing. Feed shortages and the low quality of feed are major constraints affecting animal production, particularly in the highland areas. Feed resources for livestock are obtained mainly from natural pastures (fodder and forage), crop residues, agro-industrial by-products and improved grown forages (Shapiro et al. 2015). Feed supply, in particular grass and fodder, remains a major constraint to the further expansion of the livestock population in the country. Available estimates indicate that in a good year, sufficient grazing and fodder is available for LG and MRD and in an average year only for LG livestock, while by 2028 all agro-ecological zones except LG will be deficient in these feeds if the current growth in stock numbers continues (LSA 2017).

Underfeeding and malnutrition have limited the capacity of animals to reach their genetic potential as measured in terms of birth weight and growth rate, productivity (milk and meat), mortality rate and reproductive performance. For example, under the existing farm management system, certain local cow breeds (such as the Horo cow) are reported to produce, on average, a mere 1.7 liters of milk at peak lactation compared to 4 liters when these cows are properly fed and managed (Tolera et al. 2012). Despite efforts and plans to support the feed subsector, prospects for meeting the growing feed demand remain dismal. Given the growth trend of the animal population and existing dry matter requirements per animal, feed requirements over the 15-year period from 2013 to 2018 are expected to rise to 56 million tons in the LG, 33 million tons in the MRD and 76 million tons in the MRS (LSA 2017). The future outlook for feed availability and hence livestock productivity thus remains a cause for concern. Land use policy bias against investment in commercial-scale seed and feed production constitutes one of the major constraints exacerbating the limited availability of feed resources (ILRI 2015).

A prevalence of animal diseases is another factor that hinders the realization of the potential of the livestock sector in the country. Ethiopia's major animal diseases include foot-and-mouth disease (FMD), peste des petits ruminants (PPR), tsetse-borne trypanosomosis (tryps), external parasites (Ekek), sheep and goat pox and contagious bovine pleuropneumonia (CBPP) (LSA 2017). For cattle, the major diseases are FMD, CBPP and brucellosis, while PPR, sheep and goat pox and CCPP are identified as major sheep and goat diseases. Sura and Newcastle are the major diseases affecting camel and poultry, respectively (LSA 2017). Livestock diseases have far-reaching economic repercussions, including impacts on household food security and livelihoods and significant impacts on the national economy. Animal disease constitutes the major cause of livestock morbidity and mortality, drastically reducing livestock production and productivity. The inadequacy or absence of veterinary services in rural areas – due to limited national coverage, estimated at 30 percent – causes a high average young stock mortality (15–30 percent) for all livestock species and production systems (LSA 2017).

Animal disease also leads to market restrictions that hamper Ethiopia's export of livestock and meat. Stringent animal health requirements and repeated bans imposed by importing countries regularly disrupt the country's meat and livestock exports, creating substantial costs to livestock producers, livestock traders and meat and livestock exporters (ILRI, 2015). With sanitary and phyto-sanitary (SPS) regulations and World Trade Organization (WTO) principles increasingly becoming integrated into trade policies, the continuing prevalence of animal diseases is expected to limit Ethiopia's access to international markets in meat and livestock. Although Ethiopia offers a wide range of processed and semi-processed leather products on the world market, some diseases cause a downgrading of quality and over 50 percent skin rejection rate (ILRI 2015). Animal diseases also have serious impacts on human health, with 60 percent of human diseases in the country being of animal origin (ILRI 2015). The delivery of animal health services is inadequate both in terms of coverage and quality. Major challenges in animal health services include low animal health extension coverage, inefficient animal health services, inadequate supplies of drugs and quality vaccines, and a lack of efficient quality control of drugs and veterinary supplies (ILRI 2015). The low genetic potential of indigenous animals also contributes to the poor performance of the livestock subsector. Currently, the majority of livestock found in Ethiopia are local breeds. About 98 percent of cattle, 97 percent of poultry and almost 100 percent of sheep, goats and camels are indigenous breeds (LSA 2017) characterized by low productivity. Average meat yield is estimated to be 110 kg of beef and 10 kg of mutton per animal while milk yield is about 1.5 liters

per cow over a lactation period of 6 months (i.e. 270 liters/lactation) (MoA and ILRI 2013). Average per capita consumption of milk and meat is estimated to be 17 and 8 kg, respectively (Getabalew et al. 2019 and Birhanu 2019). According to Tolera (2012), per capita consumption of milk and meat in Ethiopia are among the lowest in the world, reflecting the very low productivity of indigenous livestock.

Major challenges in marketing and processing include poor market infrastructure and roads, poor technical knowledge among value chain actors (especially processing technicians), inadequate market information and poor linkages between producers, processors and export abattoirs (ILRI 2015). The poultry industry in particular is challenged by a lack of diversity of poultry products and packaging that meets the consumption patterns of different consumers, seasonal demand fluctuations (due to fasting) leading to variations in chicken meat and egg supply and processing, attitudinal/ behavioral challenges towards consuming eggs and meat from hybrid and exotic breeds, and limited cooking and serving skills in relation to chicken meat and eggs. Price analysis along the meat and dairy value chains reveals that gross margins are quite high for processors and food service providers who are involved in value addition through processing (LSA 2017). Most of the actors in these chains are thus operating in a lucrative business environment where there is limited competition. Limited access to land and credit constitute major policy constraints hindering further and easier entry into these markets. Overall, the sector remains severely challenged by the lack of adequate incentives (tax holidays, credit facilities, training) to promote more value addition through product processing and input production.

The government of Ethiopia has introduced several policy measures and strategies to respond to the challenges and constraints faced by the livestock sector. One of these is the introduction of a new policy for pastoral development. As more than half of the country's livestock population is situated in pastoral areas, the focus of the new policy includes the livestock sector's commercialization and production diversification. Another government intervention is the development of the Livestock Master Plan. This includes a roadmap and prioritized investment interventions aimed at satisfying the projected demand for the period from 2013 to 2028. In addition, policy measures have been introduced that aim to foster the involvement of the private sector, such as tax exemptions for capital expenditure. The construction of agro-industrial parks providing better access to electric power and other services such as logistics and customs facilitation is also significant (Malabo Montpellier Panel 2020).

3. METHODOLOGY

This paper employs a spatial typology to identify interventions that help increase the production and consumption of livestock based foods. The spatial typology has been developed within the comprehensive food and nutrition security (FNS) framework, which has four dimensions: potential, availability, access, and utilization. Then, using data for each these four dimensions, we have estimated efficiency and average performance in terms of livestock production, access and utilization. A stochastic frontier approach is used to estimate the production potential for the livestock sector. A measure of efficiency is used to identify locations where investments in livestock will produce returns in terms of food security, employment, and poverty alleviation; however, nutritional status is used to set priority levels. Details of the methodology are available in Dembele et al. (2022).

4. DATA AND DESCRIPTIVE ANALYSIS

The Ethiopian Socioeconomic Survey (ESS) is a collaborative project between the Central Statistics Agency of Ethiopia (CSA) and the World Bank Living Standards Measurement Study - Integrated Surveys of Agriculture (LSMS-ISA) project. The main objective of the LSMS-ISA is to collect multi-topic household panel data with a special focus on improving agricultural statistics and the link between agriculture and household income activities. The ESS is a panel dataset of households and individuals for rural and all urban areas that has been collected in three waves over a period of time (from 2011–12 to 2015–16). The households and individuals are tracked and re-interviewed in order to establish the panel dataset. In 2011–12, the ERSS (Ethiopia Rural Socioeconomic Survey) was conducted; this was the first wave of data collection, which included 333 enumeration areas (EAs) representing 3,776 households. ESS2 was conducted in 2013–14; this covered all regional states including the capital, Addis Ababa, with 433 enumeration areas (EAs) comprising: 290 rural EAs, 43 small town EAs from ESS1, and 100 EAs from major urban areas. A total of 433 EAs representing 5,262 households were enumerated.

Table 8: Households engaged in livestock production in Ethiopia

Type of animal	Number of households	Total number of animals per species (in million)
Large Ruminants	2,618	**64.76**
Other Ruminants	2,239	**57.60**
Camels	286	**2.10**
Poultry	2,147	**51.52**
Equines	1,383	**10.57**
Bee Colony	364	**4.79**

Source: Authors' calculations from ESS3

The ESS3 conducted in 2015–16 used the same EAs as for ESS2. The ESS3 sample is a two-stage probability sample. During the first stage of sampling, the enumeration areas, which constitute the primary sampling units, were selected using simple random sampling (SRS) from the sample of the agricultural sample survey (AgSS) enumeration areas. Enumeration areas were selected based on probability proportional to size of population (PPS). About 290 of the 433 EAs in which the survey was implemented were in rural areas representing 67 percent coverage. In addition, the survey covered the Somali and Afar regions, which constitute more than 80 percent of Ethiopia's pastoralist areas. The sample can therefore be considered a thorough representation of the rural and the pastoralist areas that are the major sites of livestock production in the country. Table 8 presents the number of households engaged in livestock production by type of animal. Over 70 percent of households are engaged in the production of large and other ruminants and poultry. The large ruminants include bulls, oxen, steers, heifers, calves and cows while the other ruminants are made up of goats and sheep, and equines consist of donkeys, mules and horses.

More households in the Afar, Somali and Dire Dawa regions use water as an input (Table 9). Households in Dire Dawa are the highest users of water but have the lowest expenses (174.7 ETB) as compared to Afar and Somali where spending on water is 1,654.80 and 1,286.90 ETB respectively. This amount is more than three times the average annual cost of water (338 ETB) used in the country. Households in

the regions of Dire Dawa, Harari and Afar are the most prominent users of feeds as a livestock input. However, the Harari and Afar regions have much higher average annual expenditure on purchased feeds as compared to Dire Dawa. Households in the Gambella and Somali regions spend more on non-purchased feeds compared to households in other regions. Approximately 66 percent of households in the Benishangul Gumuz region seek veterinary services as inputs: this is three times the percentage of households that seek similar services in the Gambella region.

Table 9: Ethiopian households' input use and costs in ETB

Region	Percentage of households using this input			Average annual cost (among households that used…) in ETB		
	Water	Feed	Veterinary	Water	Purchase feed	Non-purchase feed
Tigray	4.1	17.5	40.6	266.3	1298.1	88.1
Afar	17.3	41.7	29.9	1654.8	2151.2	200.1
Amhara	2.0	23.6	47.7	259.4	854.0	67.3
Oromiya	8.7	20.2	48.5	189.2	1189.0	309.0
Somali	24.4	25.5	40.6	1286.9	2074.9	912.9
Benishangul Gumuz	2.0	2.0	65.9	36.0	60.0	175.8
SNNP	5.1	14.9	33.8	92.9	465.2	576.8
Gambella	0.0	11.6	23.2		1532.2	637.8
Harari	5.1	43.14	25.68	1244.1	2510.5	203.6
Dire Dawa	34.35	43.21	30.51	174.7	776.9	56.5
Total	**6.3**	**20.1**	**44.6**	**337.6**	**1027.4**	**275.3**

Source: Author's calculations from ESS3

The input yield provides the ratio of input per unit of output. Table 10 provides the various inputs per unit of output in ETB per tropical livestock unit (TLU). The Harari and Somali regions spend more than other regions on water per unit of tropical livestock (23.6 and 42.3 ETB per TLU). The Harari region also has a high total feed yield in ETB/TLU.

Table 10: Yield Input (ETB/TLU) in Ethiopia

Region	Water	Total Feed	Veterinary
Tigray	5.5	60.7	6.7
Afar	14.5	51	12.1
Amhara	1.4	67.7	7.8
Oromiya	4.5	39.2	32.3
Somali	42.3	59.8	30.9
Benishangul	0.1	0.2	26.4
SNNP	0.6	16.7	38.4
Gambella	0.0	8.2	13.4
Harari	23.6	379.6	16.7
Dire Dawa	16.2	96.7	6.1
Total	**4.0**	**44.7**	**24.6**

Source: Author's calculations from ESS3

Table 11 presents descriptive statistics used in the model estimation. The average annual cost of labor for livestock production is much higher compared to cost of feed and veterinary services. The average age of household heads is 47.7 years, implying that livestock farming is not carried out by many young people. Infrastructure development for access related to livestock production remains largely undeveloped. Access to a market, microfinance institution or nearest road is at least 15 km away. It is worth mentioning that not all households were found to incur costs in watering animals and buying feeds.

Table 11: Descriptive statistics of variables used in the model (Ethiopia)

Variables	Description	Sample	Mean	Std. dev.	Min	Max
Y_tluly	# of animals produced (stock+sold+slaughter): in TLU	3,254.0	4.7	5.6	0	170.7
cost_water: lx1	Annual cost for watering animals in ETB	249.0	337.6	745.5	1.0	6,500.0
cost_feed: lx2	Annual cost for feeding in ETB	633.0	1,027.4	1,384.1	1.0	16,800.0
cost_labor: lx3	Annual cost for labor in ETB	3,254.0	3,552.6	4,904.5	0	107,569.9
cost_veten~y: lx4	Annual cost for veterinary services in ETB	1,314.0	275.3	2,076.9	1.0	50,000.0
cost	Total annual cost (feed, labor, veterinary, water) in ETB	3,254	4,002.5	5,281.1	0	107,569.9
Household characteristics						
hhsize	Household size (number of persons)	3,234.0	5.4	2.2	1.0	17.0
Gender	Sex of household head (1=male)	3,236.0	0.8	0.4	0	1.0
Age	Age of household head (years)	3,231.0	47.7	14.7	15.0	97.0
cage1	If the head of household is between 15 and 39 years old	3,231.0	0.3	0.5	0	1.0
mar1	The head of household is married polygamous	3,254.0	0.2	0.4	0	1.0
mar2	The head of household is married monogamous	3,254.0	0.8	0.4	0	1.0
Alpha	Education household head (1=literacy)	3,221.0	0.5	0.5	0	1.0
Accessibility						
cs4q15	Distance to the nearest large weekly market? (Kilometers)	1,952.0	16.0	26.3	0	250.0
cs4q48	Distance to the nearest microfinance institution? (Kilometers)	2,393.0	21.7	24.6	0	175.0
dist_road	HH Distance in km from the nearest road	3,237.0	15.3	22.0	0	242.0
dist_admctr	HH Distance in (KM) of Boma from current residency district	3,237.0	181.2	119.5	1.0	773.0
Agroecological conditions						
twi	Potential humidity index	3,237.0	12.6	1.8	0	36.0
anntot_avg	Avg 12-month total rainfall(mm) for Jan-Dec	3,237.0	910.6	276.9	249.0	1,696.0

5. RESULTS AND DISCUSSION

Results from the pooled stochastic frontier are given in Table 12. Positive input parameters imply that increased usage of the inputs (water for animals, feed, labor and veterinary services) are significant in contributing to output. With respect to inefficiency, a negative sign of a variable implies that the corresponding variable would reduce inefficiency (or increase efficiency). From the results, distance to the nearest road, household size and the gender of the household head reduce inefficiency (increase efficiency) in livestock production.

Table 12: Production function estimates and determinants of technical efficiency (Ethiopia)

	Pooled Stochastic Frontier	
	Coefficient	**Std. Error**
Production Input Parameters		
Cost of Watering Animals	0.04*	0.011
Cost of Feed	0.03*	0.006
Cost of Labor	0.07*	0.007
Cost of Veterinary Services	0.49*	0.010
Constant	-2.15*	0.107
Inefficiency Effects (U-sigma)		
Log of Household Size	-0.62***	0.113
Log of Distant to Nearest Road	-0.14***	0.035
Log of Average Rainfall (mm)	1.85***	0.220
Gender of Household Head (Male=1)	-0.71***	0.163
Log of Age of Household Head (19-45 Years)	0.43***	0.100
Household Head (Monogamous)	0.31*	0.166
Household Head (Education)	0.32***	0.108
Constant	1.17***	0.207
V- sigma		
Potential Humidity (°C)	0.05***	0.017
Average Rainfall (mm)	0.28***	0.098
Constant	-3.30	0.731
E (sigma_u)	0.72	
E (sigma_v)	0.70	

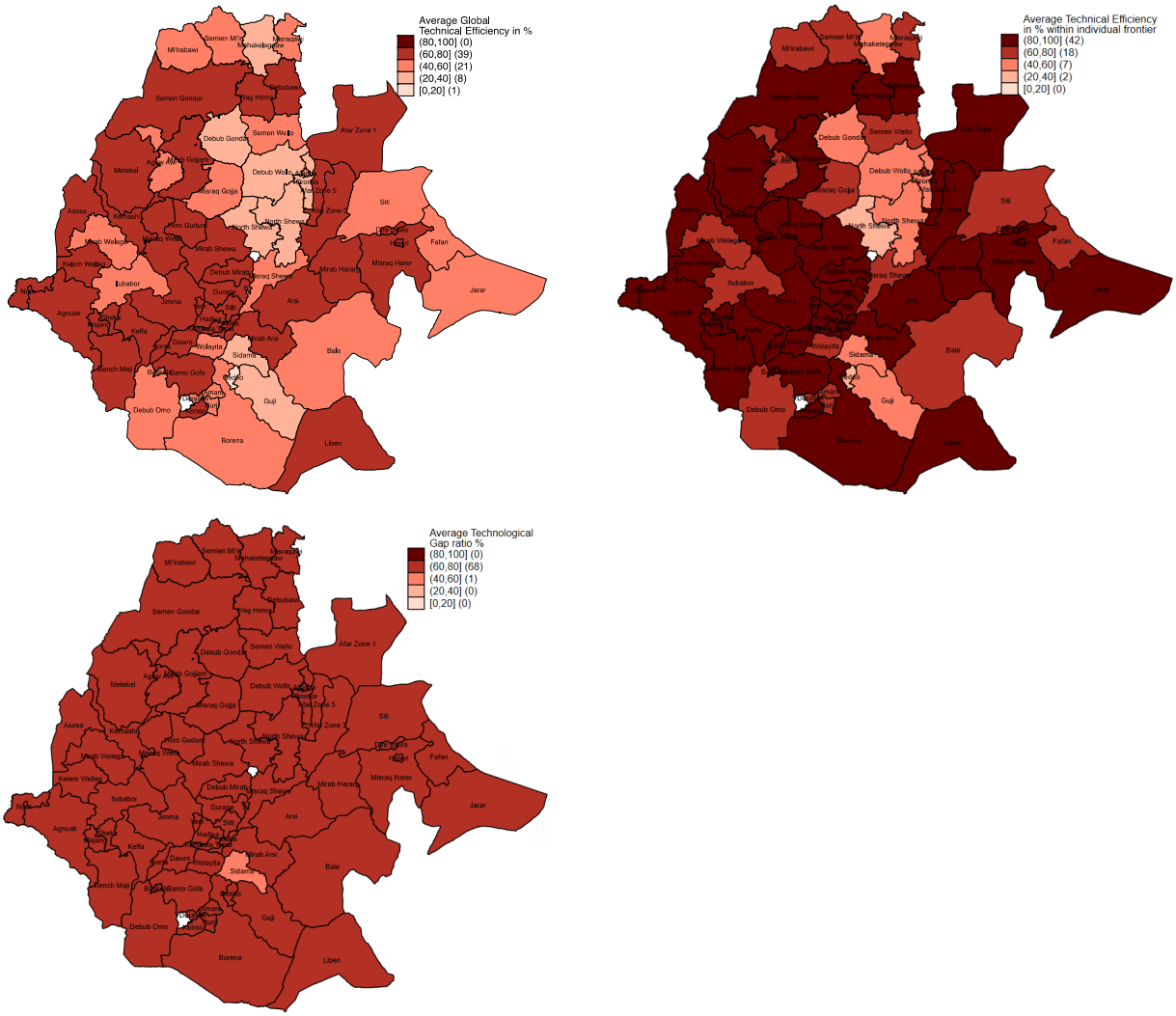
Statistically significant level at: *** 1%, **5%, * 10%,

A greater distance of a household from the nearest road is associated with lower inefficiency. It is possible that distance proxies for better grazing resources, which reduces inefficiency. Secondly, easier access to markets for both inputs and outputs also reduces inefficiency. The larger the household, the higher its efficiency in livestock production; this could be because more labor is available for livestock production. Households headed by males are associated with lower production inefficiency. Inefficiency tends to increase with age; this result could imply that better educated and older household heads tend to move away from livestock production to other sectors, thus increasing the livestock production inefficiency in terms of labor and skills required in the sector. Potential humidity and average rainfall both serve as components of the error term (v-sigma) and their sign implies that increased rainfall and humidity will increase the variance in livestock output. Therefore, average rainfall is not only a significant determinant of inefficiencies in livestock production but also increases the variance in livestock output.

It is important to note that the meta-frontier technical efficiency (MTE) measures the overall

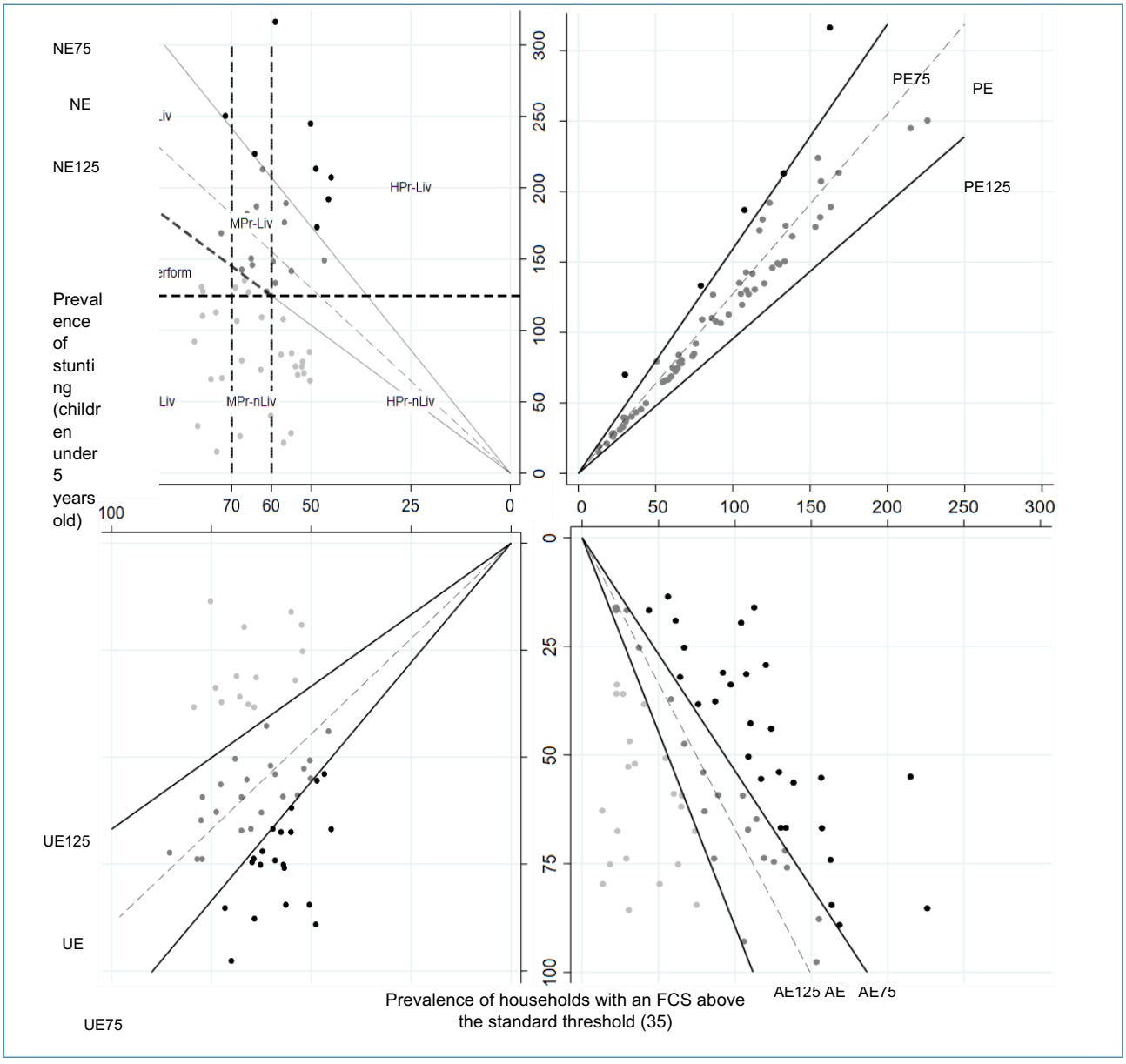
efficiency with regards to the meta-frontier for each unit of production and can be compared between farms from different technology groups. The MTE has two components: the relative technical efficiency (TE) with respect to a group's production technology and the gap between the farm specific technology and the meta-frontier, which is the ratio of the meta-frontier to the group frontier. The results suggest that the Arsi zone has an MTE of 0.75, implying that it has the scope to improve livestock production by 25 percent of the total potential (see Appendix Table 1). Arsi has a TE of 1, implying that the zone is fully efficient with respect to the adoption of technology within its zone; however, there is a technology gap ratio (TGR) of 0.25 which, if filled, will enable the zone to reach its maximum potential. Figure 9 shows that most zones in Ethiopia make the best use of the technology available in their production area. This is reflected in their internal efficiency score, which is mostly close to 1. In addition, the technology gap in relation to the best technology used in the country is quite uniform among livestock producers. All other zones have an MTE of less than 0.75. These zones thus have scope to improve livestock production by a range of 25 to 86 percent of total potential. Furthermore, they have (see Appendix Table 1) a TE ranging from 0.23 to 1. Afar Zone 1, Majang, Kemashi and Mirab Shewa zones have a TE equal to 1, implying that they are fully efficient with respect to adoption of technology within their areas. However, the technology gap ratio (TGR) for these zones ranges from 0.69 to 0.74 compared to the maximum potential of the meta-frontier. The rest of the zones have to increase the technological input and also improve the use of inputs at the level of the individual zone in order to reach their potential at the meta-frontier. For example, Gedeo has an MTE of 0.14, implying that it has scope to improve livestock production by 86 percent in order to reach its maximum potential. Within its area, it has a technical efficiency of 0.24, with a TGR of 0.72 compared to the meta-frontier.

Figure 6: Meta-frontier technical efficiency, technical efficiency and technology gap ratio in Ethiopian Zones.



Livestock production potential is derived by dividing output by the overall efficiency (MTE). From the North East (NE) quadrant, most zones in Ethiopia fall within the 75 to 125 percent production efficiency area; however, five zones are outside this range, implying that they have low production efficiency (Figure 7). With respect to access efficiency, 15 zones have more than average (greater than 125 percent) access efficiency while 26 zones perform below the average. In the North West (NW) quadrant, the nutrition poverty lines are set at 60 percent (lower bound) and 70 percent (upper bound). This allows for the distinction of zones as high priority (HPr), medium priority (MPr) and low priority (LPr) when dealing with malnutrition.

Figure 7: Dispersion chart combined with Zone-level data (Ethiopia, 2016)

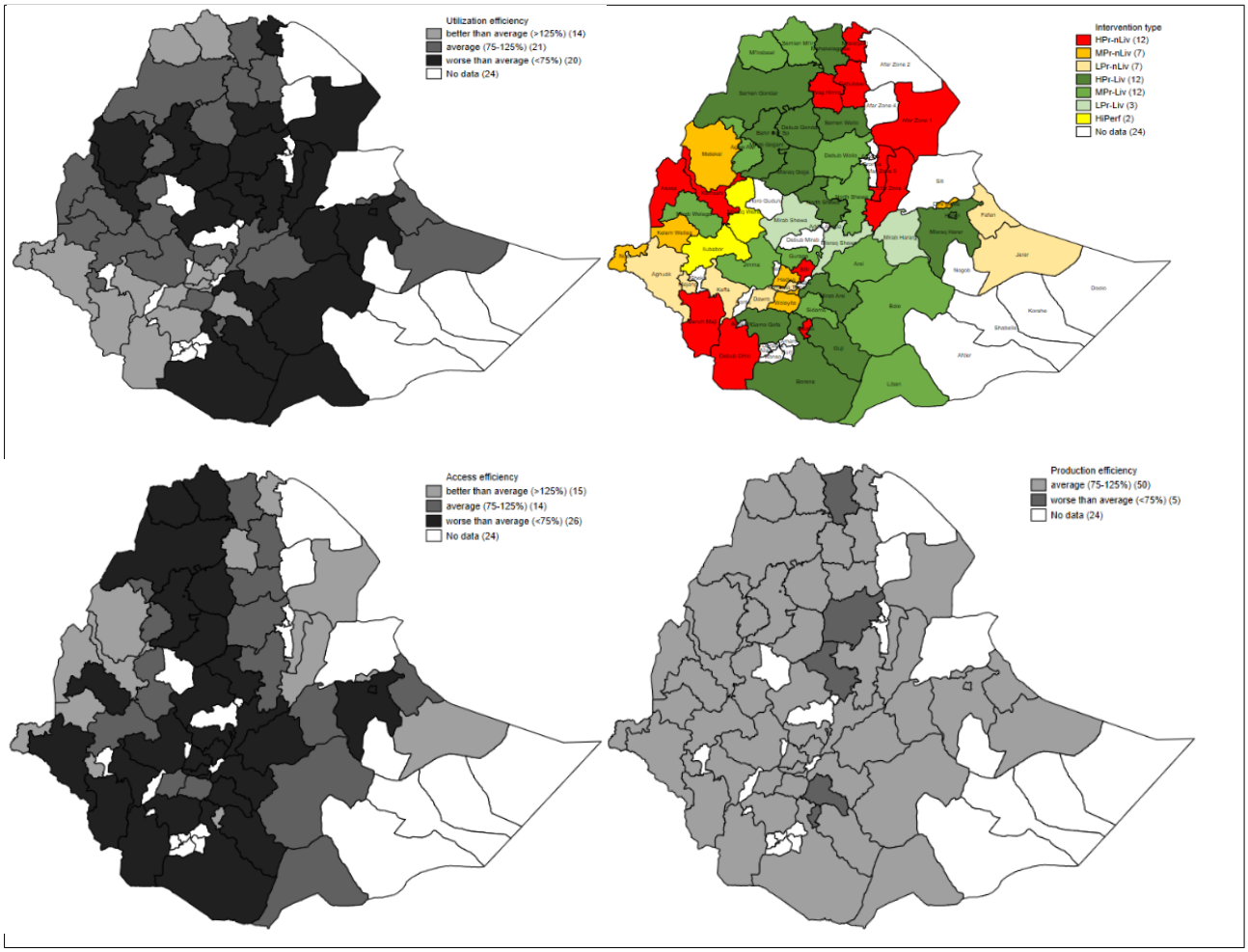


Note: LPr, MPr, HPr represent low, medium and high priority circles in terms of chronic malnutrition; Liv and nLiv indicate high and low livestock potential; and HiPerform refers to the zones with high performance. PE, AE, UE and NE are potential efficiency, access efficiency, utilization efficiency and nutrition efficiency.

Figure 8 presents four maps of Ethiopia representing required intervention types, which depend on the level of production, access and utilization efficiency. In terms of improving nutritional outcomes, zones with high priority non-livestock production include Afar Zone 1, Afar Zone 3, Afar Zone 5, Wag Himra, Asosa, Kemashi, Bench Maji, Debub Omo, Gedeo, Silti, Debubawi and Misraqawi. Even though they fall within the average production efficiency range, they have worse than average utilization efficiency and a high prevalence of child stunting incidence, ranging from 40 to 50 percent (Appendix Figure 1). Areas

considered a high priority for livestock production interventions should include: Debub Gondar, MirabGojjam, MisraqGojjam, Semen Gondar, Semen Wello, Borena, Guji, MirabArsi, MisraqHarerge, North Shewa, GamoGofa and Mehakelegnaw.

Figure 8: Type of interventions and nutrition constraints, Ethiopia Zones (2016)



Zones identified to be high priority with no livestock potential also have below average utilization efficiency, implying the need to improve nutritional outcomes in these areas (see Table 13). For most high priority zones with high livestock potential, the main challenge has been found to be market access inefficiency. Access to markets is limited in part due to low quality road infrastructure, particularly for Borena, Guji and GamoGofa, with the nearest market located at least 100 km away.

Table 13: Efficiency profile for Ethiopia

High Priority Zone	Production	Access	Utilization	Description
High Priority with no Livestock Potential				
Afar Zone 1	Average	Better	Worse	Average household size of 4.8 Households (< than 35) FCS- 27% Child stunting (height-for-age 2sd)- 50%
Afar Zone 3	Average	Better	Worse	Average household size of 5.4 Households (< than 35) FCS- 44% Child stunting (height-for-age 2sd)- 42%
Afar Zone 5	Average	Better	Worse	Average household size of 6.4 Households (< than 35) FCS- 0% Child stunting (height-for-age 2sd)- 45%
Wag Himra	Average	Better	Average	Average household size of 4.7 Households (< than 35) FCS- 49% Child stunting (height-for-age 2sd)- 50%
Asosa	Average	Better	Average	Average household size of 4.9 Households (< than 35) FCS- 41% Child stunting (height-for-age 2sd)- 47%
Kemashi	Average	Better	Worse	Average household size of 5.5 Households (< than 35) FCS- 42% Child stunting (height-for-age 2sd)- 43%
Bench Maji	Average	Worse	Better	Average household size of 5.3 Households (< than 35) FCS-68% Child stunting (height-for-age 2sd)- 46%
Misraqawi	Average	Better	Worse	Average household size of 4.7 Households (< than 35) FCS- 38% Child stunting (height-for-age 2sd)- 45%
Debub Omo	Average	Worse	Better	Average household size of 5.9 Households (< than 35) FCS- 81% Child stunting (height-for-age 2sd)- 33%
Gedeo	Worse	Better	Average	Average household size of 6.0 Households (< than 35) FCS- 47% Child stunting (height-for-age 2sd)- 30%
Debubawi	Average	Average	Average	Average household size of 5.5 Households (< than 35) FCS- 41% Child stunting (height-for-age 2sd)- 14%
Silti	Average	Worse	-	Average household size of 5.5 Households (< than 35) FCS- 72% Child stunting (height-for-age 2sd)- 31%

High Priority Zone	Production	Access	Utilization	Description
High Priority with Livestock Potential				
Debub Gondar	Average	Worse	Average	Average household size of 4.8 Distance to: Market-83.7 km; Road- 24.5 km Households (< than 35) FCS- 56% Child stunting (height-for-age 2sd)- 26%
MirabGojjam	Average	Worse	Worse	Average household size of 4.6 Distance to: Market-26.1 km; Road- 6.6 km Households (< than 35) FCS- 15% Child stunting (height-for-age 2sd)- 18%
MisraqGojjam	Average	Worse	Worse	Average household size of 4.7 Distance to: Market-51.4 km; Road- 14.2 km Households (< than 35) FCS- 33% Child stunting (height-for-age 2sd)- 19%
Semen Gondar	Average	Worse	Average	Average household size of 5.5 Distance to: Market-58.9 km; Road- 20.2 km Households (< than 35) FCS- 45% Child stunting (height-for-age 2sd)- 20%
Semen Wello	Average	Average	Worse	Average household size of 4.8 Distance to: Market-50.6 km; Road- 8.9 km Households (< than 35) FCS- 24% Child stunting (height-for-age 2sd)- 25%
Borena	Average	Worse	Worse	Average household size of 5.8 Distance to: Market-109.9 km; Road- 9.2 km Households (< than 35) FCS- 11% Child stunting (height-for-age 2sd)- 27%
Guji	Average	Worse	Worse	Average household size of 6.8 Distance to: Market-118.8 km; Road- 21.6 km Households (< than 35) FCS- 44% Child stunting (height-for-age 2sd)- 26%
MirabArsi	Average	Worse	Worse	Average household size of 6.3 Distance to: Market-30.1 km; Road- 5.5km Households (< than 35) FCS- 46% Child stunting (height-for-age 2sd)- 30%
MisraqHarerge	Average	Worse	Worse	Average household size of 6.1 Distance to: Market-31.7 km; Road- 16.9 km Households (< than 35) FCS- 33% Child stunting (height-for-age 2sd)- 16%

High Priority Zone	Production	Access	Utilization	Description
North Shewa	Worse	Worse	Worse	Average household size of 5.3 Distance to: Market-27.7 km; Road- 3.5 km Households (< than 35) FCS- 26% Child stunting (height-for-age 2sd)- 14%
GamoGofa	Average	Worse	Better	Average household size of 5.8 Distance to: Market-151.3 km; Road- 20.5 Households (< than 35) FCS- 83% Child stunting (height-for-age 2sd)- 24%
Mehakelegnaw	Worse	Average	Average	Average household size of 5.5 Distance to: Market-58.3 km; Road- 8.7 km Households (< than 35) FCS- 46% Child stunting (height-for-age 2sd)- 15%

Average (75-125%); Worse (< 75%); Better (>125%); FCS- Food Consumption Score
Source: Author's calculations from ESS3

6. POLICY IMPLICATIONS

The following policy implications are drawn from the two case studies. Overall, feed, water and veterinary services emerged as key elements of livestock production. Veterinary services have a very high elasticity, implying that if the government were to put more resources into these services, livestock production would increase. Water supply and animal feed are also key components. The provision of subsidies for animal feed as well as policies geared towards increased water supply for livestock production should enhance livestock production efficiency.

Governments should use more innovative approaches to livestock production, with increased automation offsetting increased demand for labor at the household level. Livestock production and productivity can be enhanced by providing households with appropriate and affordable technologies and skills. Location, household size and gender are the main factors found to play a significant role in the economic efficiency of livestock keepers. Support for entrepreneurial skills and innovation among livestock keepers can also help to develop the sector.

The findings also suggest that low livestock potential is correlated with a low level of food and nutrition security. Low livestock potential is attributed to a lack of natural feedstock and access to commercial feed, and this affects the entire livestock value chain. Therefore, livelihood conditions and nutritional status of the population could be improved by introducing and increasing fodder cropping, and encouraging breeders to improve veterinary practices in breeding areas for the better management of animal health and the development of the livestock value chain. Policymakers should consider pathways to promote and scale up fodder crop production, and to develop the collective marketing of animal and animal products. In terms of production efficiency, interventions should focus on the prices of livestock inputs and infrastructure, which could include introducing subsidies for these. In addition, the capacity of livestock keepers could be strengthened through vocational training and networking with animal input suppliers. Policymakers should also invest in livestock infrastructure, market creation and capacity building to address inefficiencies related to market access and high transaction costs. This would improve the potential of trade in livestock to contribute to economic growth and poverty reduction, food security and better nutritional outcomes.

Different sectoral interventions are required depending on the type of location and the existing breeding potential. In areas with low breeding potential, the focus should be on alternative income-generating activities. This implies the existence of adequate infrastructure for distribution, processing and transport. For areas with high breeding potential, emphasis should be placed on the availability of food and health inputs over time, and space for improved

livestock productivity. In addition, fodder and hay production should be encouraged to help producers cope with periods of fodder deficits. It is also important to encourage limited herd sizes so that producers can achieve the maximum potential out of their livestock in accordance with available resources. In both cases, governments must promote the control and management of water but also facilitate transactions between the various actors in the milk and meat value chains.

Interventions at the production level should target access to equipment for producers and facilitate their access to credit and quality inputs, as well as subsidizing animal inputs, particularly feed. Strategies should increase incentives for behavior change among livestock keepers, including through the sharing of successful experiences of intensifying livestock production systems. Public-private partnerships should be promoted as a way of attracting private investment for the modernization of slaughterhouses and of introducing policies to boost meat exports and increase compliance with international standards. Such partnerships would also help to establish strong networks among producers, traders, market and other agents in the livestock value chain.

The findings also show that Ethiopia has very low per capita consumption of livestock products. A number of interventions are required to address this, including measures to improve the nutritional knowledge of households through awareness raising. One route for this is agriculture extension services, which can be made more nutrition sensitive. Interventions of this nature will help improve household-level understanding of nutrition issues and influence consumption patterns, which in turn can positively affect the quality of household diets. Finally, to improve the affordability of livestock products, the government should also introduce policies that focus more broadly on raising household income.

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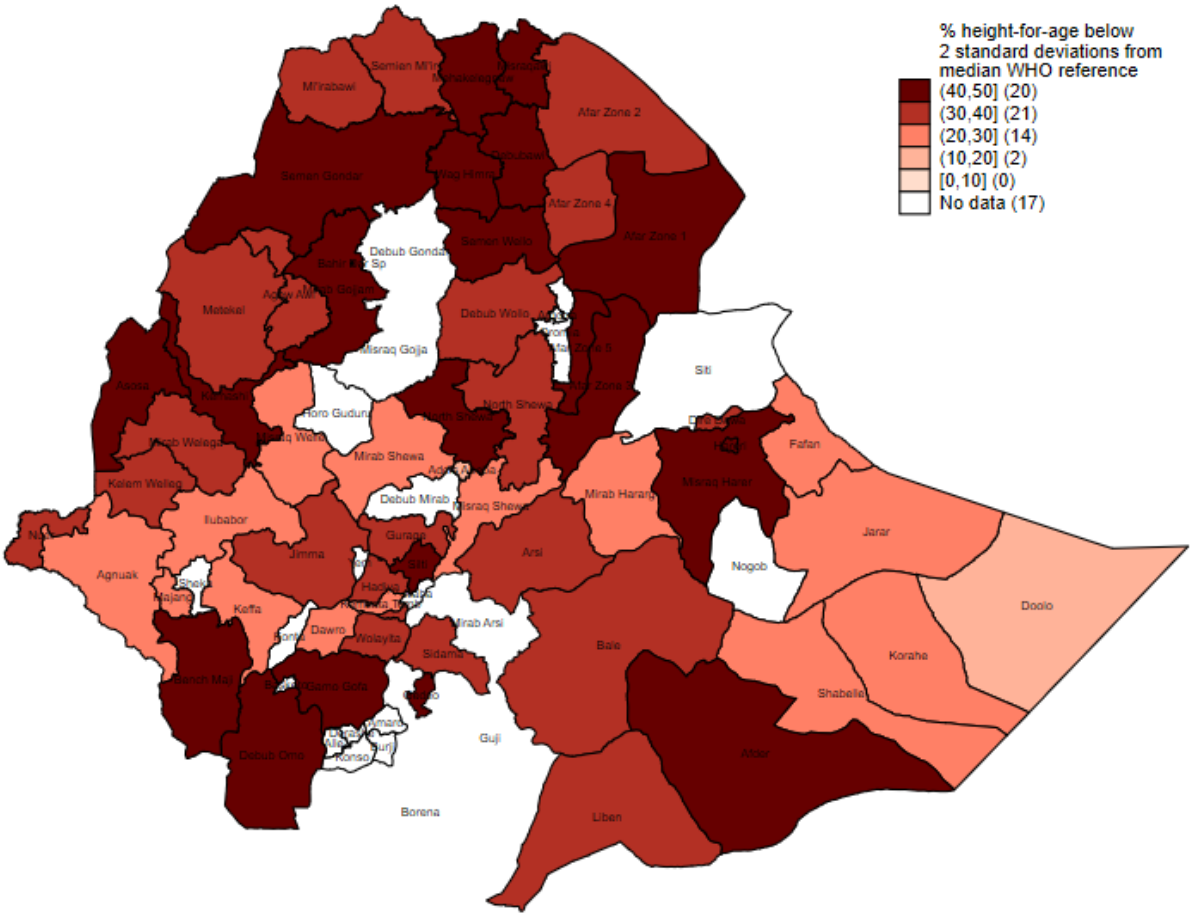
8. APPENDIX

Appendix Table 1: Technical Efficiency, TGR and MTE

Zone	Average			Standard Deviation		
	TE	TGR	MTE	TE	MTE	TGR
Afar Zone 1	1.000	0.676	0.676	0.000	0.111	0.111
Afar Zone 3	0.873	0.705	0.635	0.157	0.114	0.166
Afar Zone 5	0.927	0.658	0.612	0.081	0.082	0.110
AgewAwi	0.744	0.748	0.555	0.195	0.032	0.144
Argoba	0.619	0.751	0.457	0.301	0.057	0.209
Debub Gondar	0.562	0.714	0.391	0.280	0.074	0.195
Debub Wollo	0.534	0.699	0.355	0.295	0.108	0.182
MirabGojjam	0.966	0.750	0.725	0.103	0.045	0.086
MisraqGojjam	0.715	0.729	0.515	0.237	0.055	0.165
North Shewa	0.547	0.727	0.386	0.288	0.075	0.194
Oromia	0.408	0.788	0.310	0.295	0.062	0.218
Semen Gondar	0.876	0.755	0.671	0.175	0.124	0.189
Semen Wello	0.722	0.747	0.537	0.229	0.022	0.169
Wag Himra	0.909	0.772	0.699	0.185	0.034	0.143
Asosa	0.956	0.765	0.731	0.097	0.037	0.080
Kemashi	1.000	0.735	0.735	0.000	0.034	0.034
Metekel	0.997	0.745	0.742	0.010	0.046	0.044
Dire Dawa	0.925	0.712	0.665	0.055	0.093	0.098
Agnuak	0.999	0.699	0.700	0.011	0.054	0.052
Majang	1.000	0.733	0.733	0.000	0.036	0.036
Nuer	0.915	0.791	0.726	0.263	0.016	0.214
Hareri	0.966	0.730	0.701	0.164	0.124	0.156
Arsi	0.994	0.759	0.755	0.014	0.097	0.100
Bale	0.620	0.735	0.453	0.182	0.057	0.123
Borena	0.826	0.724	0.594	0.232	0.065	0.169
Debub Mirab Shewa	0.988	0.725	0.716	0.041	0.145	0.148
Guji	0.485	0.762	0.375	0.160	0.047	0.134
HoroGuduru	0.951	0.754	0.724	0.115	0.153	0.157
Ilubabor	0.772	0.730	0.575	0.204	0.120	0.190
Jimma	0.917	0.746	0.681	0.249	0.023	0.185
KelemWellega	0.842	0.749	0.639	0.139	0.096	0.155
MirabArsi	0.876	0.752	0.664	0.115	0.076	0.125
MirabHararghe	0.978	0.738	0.723	0.088	0.067	0.101
Mirab Shewa	1.000	0.742	0.741	0.001	0.152	0.152
MirabWelega	0.767	0.729	0.573	0.227	0.101	0.206
MisraqHarerge	0.964	0.756	0.731	0.127	0.062	0.117
Misraq Shewa	0.786	0.745	0.590	0.179	0.045	0.149
MisraqWellega	0.946	0.745	0.710	0.130	0.130	0.168
North Shewa	0.380	0.658	0.248	0.144	0.056	0.107
Fafan	0.786	0.757	0.593	0.137	0.073	0.118
Jarar	0.877	0.667	0.592	0.135	0.104	0.142
Liben	0.823	0.733	0.605	0.136	0.071	0.140

Zone	Average			Standard Deviation		
	TE	TGR	MTE	TE	MTE	TGR
Siti	0.800	0.724	0.577	0.127	0.093	0.118
Alaba	0.934	0.766	0.716	0.067	0.040	0.077
Amaro	0.679	0.740	0.505	0.080	0.045	0.085
Basketo	0.815	0.716	0.578	0.099	0.128	0.102
Bench Maji	0.921	0.743	0.688	0.173	0.051	0.142
Burji	0.732	0.779	0.573	0.079	0.049	0.088
Dawro	0.967	0.736	0.715	0.057	0.084	0.107
Debub Omo	0.707	0.719	0.532	0.109	0.117	0.112
Derashe	0.662	0.705	0.481	0.147	0.117	0.175
GamoGofa	0.824	0.742	0.604	0.092	0.151	0.120
Gedeo	0.236	0.718	0.140	0.242	0.152	0.122
Gurage	0.935	0.739	0.694	0.116	0.102	0.135
Hadiya	0.981	0.716	0.712	0.044	0.108	0.092
Keffa	0.957	0.756	0.724	0.086	0.023	0.074
KembataTembaro	0.954	0.748	0.714	0.062	0.023	0.054
Konso	0.803	0.766	0.617	0.120	0.078	0.119
Konta	0.875	0.751	0.658	0.130	0.006	0.100
Sheka	0.864	0.732	0.634	0.140	0.038	0.111
Sidama	0.579	0.589	0.324	0.322	0.148	0.182
Silti	0.930	0.757	0.705	0.064	0.043	0.075
Wolayita	0.718	0.744	0.531	0.193	0.049	0.141
Yem	0.957	0.748	0.718	0.109	0.090	0.128
Debubawi	0.952	0.720	0.683	0.151	0.058	0.119
Mehakelegnaw	0.533	0.665	0.335	0.284	0.134	0.184
Mi'irabawi	0.661	0.682	0.436	0.308	0.076	0.221
Misraqawi	0.718	0.740	0.535	0.160	0.105	0.146
SemienMi'irabaw	0.673	0.748	0.507	0.224	0.048	0.178

Appendix Figure 1: Prevalence of stunting among children under five in Ethiopia Zones



Source: Authors calculations from DHS (2016).

Annex 1: Methodology for projecting future production and consumption

The LSA (2017) made projections of future production and consumption for the major livestock products (meat and milk) without any policy or technology interventions (the 'BAU' scenario) to assess the size of the future supply and demand gaps. The parameters used in demand projections are i) the size of the human population and its growth rate, ii) the size and growth in per capita GDP, iii) the baseline consumption levels for meat and milk, and iv) the income elasticities of demand for meat and milk. In the case of the supply projections for meat and milk, the parameters are from the herd growth model in LSIPT (Livestock sector and investment policy toolkit)[2].

Future projection growth rates were calculated assuming the past annual growth rate for real per capita GDP. The CSA 2007–2037 population projection for a medium variant population growth scenario was used to project human population growth. The annual trend growth rate for real per capita GDP of 8 percent was obtained by taking the difference between the GDP and population growth rates over the last seven years (2007–2013). Accordingly, given the income elasticity of demand (η) for a given livestock product, trend annual growth rates (γ) of real per capita GDP, and baseline per capita consumption (LC_0) of a given livestock product, the projected per capita livestock product consumption (LC_t) for a given year (t) is based on the following formula:

$$LC_t = LC_0 * (1+\eta*\gamma)^t$$

Finally, the projected total consumption TLC_t of a given livestock product in time period is obtained by multiplying the projected per capita consumption with the projected population for a given time period (t)):

$$TLC_t = LC_t * (1+\eta*\gamma)^t * POP_t$$

The results provide projections of the production and consumption of meat and milk over the coming 15 years without any investment interventions.

2 The LSIPT consists of a set of tools (mathematical models, format questionnaires, and other aids), that have been field tested and reviewed—most notably in Zambia. It enables in-depth and systematic quantitative analysis of the major constraints facing the livestock sector, and the effects of proposed interventions on economic growth and poverty alleviation (LSA, 2017).

The projection of future production and consumption of livestock products constitutes the basis for assessing the magnitude of required future investment in livestock research and development interventions (policies and technologies), required to close any production-consumption gaps. The nature and cost of envisaged investments are shown in Table A2 below.

Investment interventions and total investment costs

The total investment costs required to carry out the LMP roadmap are ETB 7762 million. The proportion of investment from the public and private sectors is 57 percent (ETB 4463 million) and 43 percent (ETB 3299 million) respectively.

Appendix Table 2: Investment interventions and total investment cost

Investment interventions	Total investment cost in ETB (millions)			Cost in USD (Millions)
	Public	Private	Total	
Cow dairy development	830	1010	1840	92
Red meat-milk and feedlot development	3175	319	3494	174.7
Poultry development	458	1970	2428	121
Total	**4463**	**3299**	**7762**	**387.7**

Source: ILRI (2015)

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