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CARLOS SERÉ

Investing Sustainably in African Livestock Development:
Opportunities and Trade-Offs



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Investing Sustainably in African Livestock Development

Opportunities and Trade-Offs

Carlos Seré

Abstract

The production and consumption of animal source foods is central to the ongoing discussion of global food systems. The objectives of this report are first to describe the patterns and changing structures of the Sub-Saharan Africa (SSA) livestock sector and secondly to explore innovations that can help to address the complex trade-offs involved in investing in the development of a sustainable livestock sector. The report reviews trends in consumption, production and trade of major livestock commodities and feed in the four subregions of SSA and presents an overview of key issues facing the sector. A scenario for the SSA livestock sector in 2030 is developed using the IMPACT model. It shows significant growth of production across all major livestock commodities with poultry and pork growing faster than ruminant meat production. A series of technical and institutional innovations show opportunities to address the challenges of sustainably intensifying livestock production in SSA. They include improved forages, improved fodder conservation, artificial insemination combined with estrus synchronization, intensive beekeeping, livestock masterplans, livestock asset transfer programs, index-based livestock insurance and livestock market information systems. The report concludes that livestock plays multiple key roles in the food systems in SSA and will continue to do so in the coming years. The complexity of the system and the multiple trade-offs imply a need for policy makers to shift from frequent “benign neglect” to actively invest in the analytical capacity to understand the changing roles and issues in SSA livestock development. In spite of important divergences on the future role, opportunities and risks associated with livestock production and consumption, developed economies and SSA nations will benefit from international scientific cooperation to jointly tackle the complex issues facing livestock production as part of the envisaged global food system.

Keywords: livestock, Sub-Saharan Africa, production systems, climate change, food systems, technical and institutional innovations, ruminants, monogastrics, scenario 2030.

JEL Codes: O13, O30, O33, Q16, Q18

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List of Acronyms

AfDB	African Development Bank
AI	Artificial Insemination
ALIVE	African Partnership for Livestock Development
ATA-EAAP	Agricultural Transformation Agency-Ethiopian Agribusiness Accelerator Platform
CIRAD	Agricultural Research for Development
DNPIA	Direction Nationale des Productions et des Industries Animales
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
GDP	Gross Domestic Product
GHG	Greenhouse gas emission intensity
IBLI	Index-Based Livestock Insurance
ICIPE	International Centre of Insect Physiology and Ecology
IER	Institut d'Economie Rurale, Mali
IGAD	Intergovernmental Authority on Development
ILRI	International Livestock Research Institute
KALRO	Kenya Agriculture and Livestock Research Organization
KAZNET	Kenyan Crowd-Sourced Livestock Market Information System
LAC	Latin America and the Caribbean
LSIPT	Livestock Sector Investment and Policy Toolkit
LSMS	Living Standards Measurement Study
MOYESH	More Young Entrepreneurs in Silk and Honey
NCD	Non-Communicable Disease
NDC	National Defined Contributions
NGO	Non-Governmental Organization
NLMIS	Kenya National Livestock Market Information System
OIE	World Organization for Animal Health (Office International des Epizooties)
OMA	Observatoire du Marché Agricole
PFP	Pigs for Peace
RCP	Representative Concentration Pathway
SDG	Sustainable Development Goals
SIPE	Satellite Index-Insurance for Pastoralists in Ethiopia
SMS	Short Messaging Service
SNV-ASPIRE	SNV-Apiculture Scaling-Up Programme for Income and Rural Employment
SPS	Sanitary and Phytosanitary Measures
SSA	Sub-Saharan Africa
TLU	Tropical Livestock Units
USAID	United States Agency for International Development
WB	The World Bank
WFP	World Food Program
YESH	Young Entrepreneurs in Silk and Honey

1 Introduction

Humans and livestock have developed efficient ways of utilizing natural resources, particularly rangelands, which they share with diverse wildlife, including large wild ruminants. Africans have developed mixed crop livestock systems that efficiently use natural resources to produce crops and animal products. Growth of human and animal populations has led to an increased competition for land, increased conflicts among ethnic groups, competition with wildlife and an increasing pest and disease burden being exchanged among humans, domestic animals and wildlife.

In line with what is happening globally, high population growth, rapid growth in income and urbanization are creating large demand increases in Sub-Saharan Africa (SSA) for livestock-derived foods among a population presently consuming low levels of animal protein. This surge in demand has been called by some “the livestock revolution” (Delgado et al., 1999).

Livestock production, in all its diverse forms, contributes to the livelihoods of large numbers of people in Africa and provides limited levels of animal protein to African consumers, thereby supplying highly bioavailable micronutrients such as iron. Livestock keepers are frequently poor and operate under conditions in which options for alternative incomes are limited.

The production and consumption of animal source foods is central to the ongoing discussion of global food systems (Willett et al., 2019). Existing criticism is rooted in the inefficiency of converting concentrate feed into animal products, the greenhouse gas (GHG) emission intensity of keeping livestock and the land use change caused by producing necessary feed crops such as soybean and maize as well as planted forages to feed animals. On the consumption side, concerns relate to non-communicable diseases associated with Western lifestyles and diets rich in animal-source foods, to animal welfare, to the extensive use of antibiotics in intensive animal production settings and to the transmission of zoonoses.

Over the course of the last few decades, the livestock sector in industrialized economies has undergone major changes driven by growing incomes, demand for animal-source foods, dramatic increases in crop productivity, globalization and declining transport costs enabling access to frequently imported feedstocks. The social, economic and environmental consequences and boundaries of these developments are leading to a change in paradigm. The emerging food-systems concept encompasses a holistic view from „farm-to-fork”: replacing chemical inputs with life sciences knowledge, particularly genetics; applying theories from circular economy; and considering social, environmental, nutritional and health dimensions.

As agriculture has progressed, livestock’s roles and functions have changed significantly:

- a. From multi-purpose animals providing animal traction, meat, milk, hides, manure, and serving as a store of wealth and a cultural asset to becoming a highly specialized producer of animal protein.
- b. From being a grazer/browser and user of crop by-products not directly eaten by humans to becoming a consumer of grain and protein cakes competing directly with human consumption.
- c. From contributing critical amino acids and micronutrients in largely plant-based human diets to becoming a major dietary component contributing to obesity and the rise in non-communicable diseases.

Policy makers in SSA are facing challenging decisions when considering interventions in the livestock sector. On the one hand, the rapidly growing demand creates opportunities for income generation and livelihoods linked to livestock value chains. This is particularly the case in rural areas with limited alternative employment opportunities, such as in drylands. On the other hand, it is well known that ruminant animals fed low-quality roughage diets have low productivity and particularly high GHG emissions intensity. For this reason, livestock are an important source of GHG emissions in many Sub-Saharan countries. An alternative to ruminant sources of animal protein is the development of the

monogastric sector (poultry and pigs). These species have a lower GHG emission intensity than ruminant animals but require energy-dense diets. Their diets are based on cereals and protein from oil cakes that can also be used for direct human consumption and therefore tend to be costly in African settings.

The objectives of this report are first, to describe the *patterns and changing structures* of the SSA livestock sector, and secondly to explore *innovations* that can help address the complex trade-offs involved in investing in the development of a sustainable livestock sector.

2 The Sub-Saharan Livestock Sector

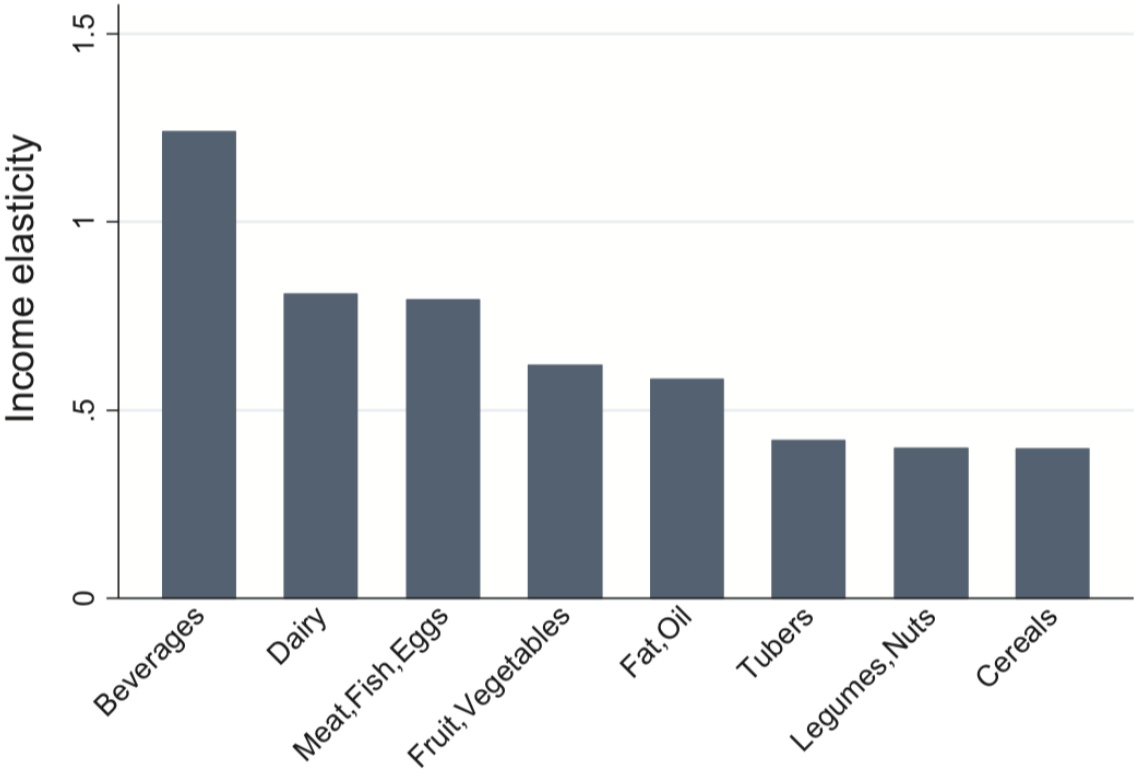
2.1 Demand: The main driver of livestock development

While the Green Revolution was largely driven by science and policies responding to food needs through plant breeding and input supplies, the livestock revolution has been driven by the rapidly growing market demand for animal-source foods caused by population and income growth as societies become wealthier and more urban. In SSA, the population growth of about 3% p.a. has been the main source of demand growth.

The African commodity boom of the last decade has led to growth in per-capita GDP (Gross Domestic Product) in a number of countries at rates between 3 and 5% p.a. Table 1 presents selected indicators driving the evolution of demand for livestock commodities in SSA. Regional country groupings follow the FAO classification (see Annex 1).

Rapid urbanization and income growth are shifting food preferences of African consumers towards fruits, vegetables and oils as well as meat and dairy products. Colen et al. (2018) present a meta-analysis of the literature on income elasticities for Africa with detailed information for individual food groups and nutrients disaggregated by region. This analysis confirms high income elasticities for dairy and meat across the continent (0.8 to 0.5), surpassed only by the income elasticity for beverages (above even 1.0; see Figure 1).

Figure 1: Predicted Income Elasticities by Food Group



Source: Colen et al., 2018

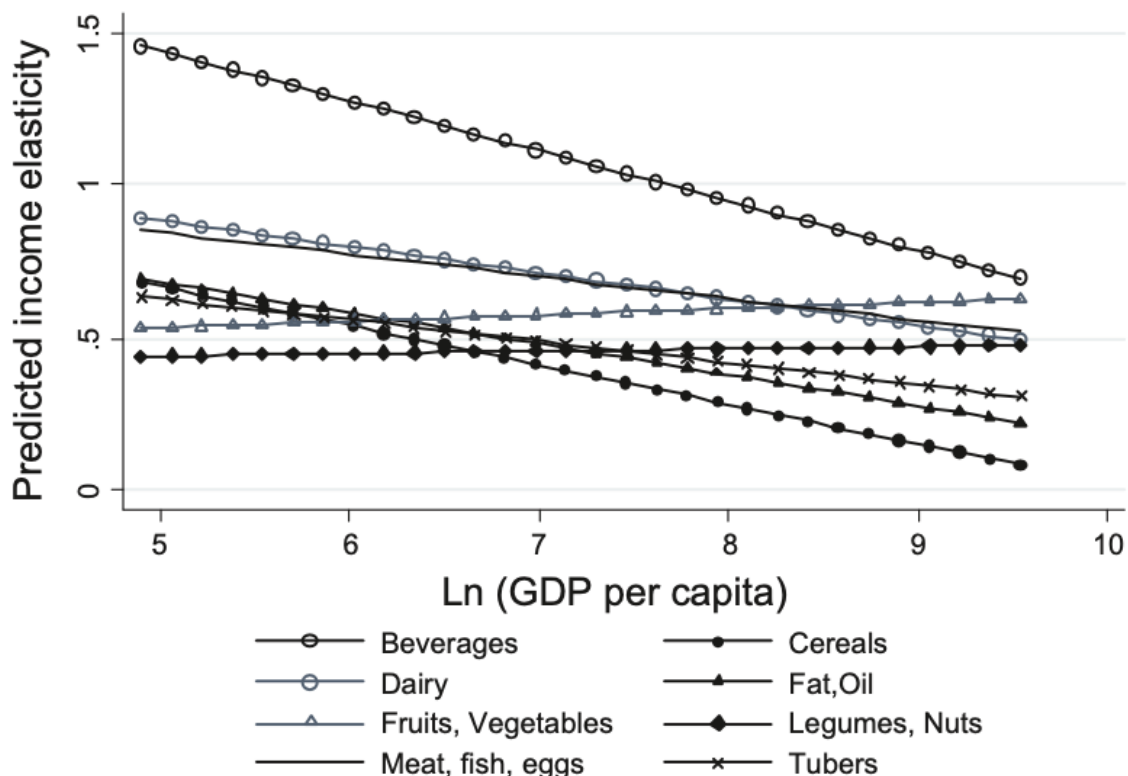
Tab 1: Drivers of Animal-Source Food Demand in SSA: Population, Income and Urbanization

Sub-Region	Total human population		Population growth rate	Rural population	Share of rural population	Selected countries in the sub-region	GDP per capita growth rate
	2008	2018	2008-18	2018	2018		Avg 2011-18
	millions		% pa	millions	%		%
Eastern Africa	312,149	422,563	3.07	312,328	73.9	Ethiopia	6.7
						Kenya	3.0
Middle Africa	123,378	169,122	3.20	85,055	50.3	D. R. Congo	2.0
						Cameroon	2.0
Southern Africa	56,776	65,739	1.48	24,004	36.5	South Africa	0.2
						Namibia	1.6
Western Africa	290,677	381,202	2.75	204,792	53.7	Mali	1.2
						Nigeria	0.6
Sub-Saharan Africa	782,980	1,038,627	2.87	626,178	60.3		0.8
Africa	987,623	1,275,921	2.59	740,318	58.0		

(FAOSTAT 2019; World Bank, 2019)

Within SSA countries, higher income levels still show income elasticities for livestock-derived foods of around 0.5 (Figure 2). This meta-analysis thus supports the expectation of substantial growth in SSA demand for livestock-derived foods, particularly if per-capita income levels continue to rise.

Figure 2: Predicted Income Elasticities by Food Group and Income Level



Source: Colen et al., 2018

Per-capita consumption of animal-source foods has largely remained at constant levels for several decades (Table 2). The major change over time has been the per-capita consumption of poultry meat, which has tripled in Middle Africa and almost doubled in Southern Africa from 2000 to 2013. Southern Africa clearly shows markedly higher levels of consumption of most meats and milk in line with higher per-capita incomes. Eastern Africa has relatively high consumption levels of milk and low but stable levels of meat consumption. In broad terms, the region has managed to maintain per-capita consumption levels for the rapidly growing population, though these levels are low when compared to other developing regions across the globe.

The above-described average per-capita consumption levels mask a skewed distribution of consumption across the population. This means that an important share of the population does not have adequate access to animal protein to ensure a healthy, well-balanced diet. This is reflected in the high proportion of women of child-bearing age with anemia as well as the share of children under 5 years with stunting. Table 3 depicts average levels of total protein and animal-source protein as well as the prevalence of anemia among women of reproductive age and stunting among children under 5 years of age. In most countries, both indices have slightly improved over time. The regional differences are still quite marked, with Southern Africa showing lower levels of anemia in women and stunting in children than the other sub-regions. This is in line with the higher per capita supply of animal protein in Southern Africa.

Tab 2: Per-Capita Consumption Levels of Meats, Dairy and Eggs in 1990, 2000 and 2013 by SSA Region

Sub-Region	Meat (Total Aggregated)			Bovine Meat			Mutton/Goat Meat			Pork			Poultry			Dairy (excl. butter)			Eggs		
	1990	2000	2013	1990	2000	2013	1990	2000	2013	1990	2000	2013	1990	2000	2013	1990	2000	2013	1990	2000	2013
	kg/capita/year																				
Eastern Africa	11.4	10.1	10.8	5.8	5.3	5.2	1.7	1.2	1.4	1.0	1.3	1.5	1.6	1.5	1.6	32.2	26.8	40.4	1.1	0.9	1.0
Middle Africa	16.6	17.4	23.9	8.2	8.0	6.8	1.6	1.9	1.9	1.9	1.9	4.0	1.9	2.8	8.5	23.3	17.2	15.3	0.6	0.6	0.6
Southern Africa	38.7	39.8	60.0	16.4	13.6	16.7	4.7	4.7	4.1	3.3	2.5	3.9	13.7	18.3	33.9	59.3	54.9	57.5	3.9	4.9	6.5
Western Africa	10.6	10.8	12.8	3.4	3.1	3.3	2.1	2.7	2.8	1.0	1.1	1.3	1.8	1.9	3.4	14.7	13.9	19.0	2.2	2.2	2.5
Africa	14.7	15.7	19.0	6.2	6.0	6.3	2.5	2.8	2.8	1.0	1.1	1.5	3.3	4.2	6.7	36.6	37.0	43.8	2.2	2.1	2.7

(FAOSTAT, 2019)

Tab 3: Per Capita Access to Total and Animal-Source Protein and Related Nutritional Status Indicators by Sub-Region

Sub-Region	Average protein supply		Average supply of animal protein		Country within each region	Prevalence of stunting, height for age		Prevalence of anemia among women of reproductive age	
	1999-2001	2011-2013	1999-2001	2011-2013		2010	2018	2010	2016
					g/cap/day		% of children under 5 years	% of women 15-49 years	
Eastern Africa	48.8	50.5	10	9	Tanzania	42.1	31.8	40.2	37.2
					Malawi	47.3	39.0	32.3	34.4
Middle Africa	25.1	30.4	6	8	DR Congo	43.4	42.7*	47.2	41.0
					Cameroon	32.6**	28.9	42.4	41.4
Southern Africa	73.5	81.4	24	33	South Africa	27.2***	27.4****	26.7	25.8
					Namibia	22.7*		26.6	23.2
Western Africa	57.6	64.5	10	12	Mali	27.8	26.9	56.8	51.3
					Nigeria	35.8**	36.8	40.2	37.2
Sub-Saharan Africa	49.3	54.6	10	11					
Africa	56.4	61.4	12	14					

* 2013
 ** 2011
 *** 2012
 **** 2016

(FAOSTAT, 2019)

2.2 Livestock production

2.2.1 *The livestock sector in Sub-Saharan Africa: A short sub-regional synthesis*

Given the number and diversity of countries in SSA, this report presents data by geographic sub-region. The allocation of countries to the four sub-regions follows FAOSTAT grouping of countries, see Annex 1.

Eastern Africa is the premier sub-region of Africa in terms of the size and diversity of its ruminant livestock sector. Production systems range from a vast pastoralist sector in the drylands to mixed crop-livestock-farming in higher rainfall regions and to mainly pasture-based dairy systems, frequently cut-and-carry smallholder systems, in the East African Highlands. High numbers of impoverished livestock keepers make the livelihoods dimension of the livestock sector particularly important in this region.

Western Africa is comprised of countries with a Sahelian ecosystem that extensively produce large and small ruminants as well as coastal countries that mainly buy live animals from the Sahel. Milk production is limited to household consumption or produced in peri-urban settings of larger cities. Imports of dairy products and poultry are particularly prevalent in the coastal areas.

Southern African livestock systems are mainly based on rangelands, both communal and operated by commercial ranches. One of the main challenges is the dualistic structure, where smallholders and communities interact with commercial operations. These countries have negotiated trade deals with Europe that require them to comply with a range of sanitary and phytosanitary (SPS) measures. These impose significant costs on the sector, including fencing in order to separate the ranching sector from communal livestock keepers. The population is largely urban and the consumption levels of livestock-derived foods are significantly higher than in the rest of SSA, reflecting the middle-income status of most of the region.

Middle Africa is composed of two distinct ecosystems: the Sahelian drylands in the north and the Congo Basin rainforest in the south. Livestock production is mainly located in drier environments (Chad, Central African Republic, northern Cameroon). Economies in this region are frequently highly dependent on oil or mineral exports. Per-capita GDP is often high, and countries rely heavily on imports of livestock-based commodities.

2.2.2 *Meat production*

While Africa's livestock sector only showed moderate growth in the 1990s, the 2000s was a period of strong growth in most regions. Eastern Africa currently has the largest livestock numbers followed by Western Africa. Middle Africa has significantly lower livestock numbers but has been growing rapidly. Southern Africa is the slowest-growing region, where only poultry numbers have increased since 2000. Cattle are particularly important in Eastern Africa, while the largest stocks of small ruminants are found in West Africa. The growth of sheep stocks in Middle Africa, albeit from a small base, is particularly striking (see Table 4).

In terms of production volumes, beef is the most important meat at the continental level, followed closely by chicken. Small ruminant meats and pig-meat are of less importance in the aggregate. In Southern Africa the volume of chicken meat is the largest of the different meats produced. Small ruminant meat, pork and chicken meat are growing faster than beef. Among the sub-regions, production in Middle Africa is growing at the highest rates (Table 5).

Tab 4: Stock Number of Major Livestock Species by Sub-Region

Sub-Region	Cattle			Goats			Sheep			Pigs			Chickens		
	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17
	million head														
Eastern Africa	88.4	96.7	163.9	69.1	65.5	140.7	52.2	42.1	91.8	5.10	6.83	13.87	217.6	246.5	369.7
Middle Africa	16.2	19.9	43.0	13.3	18.9	53.1	7.0	8.0	35.1	3.89	4.17	7.70	62.1	65.2	126.3
Southern Africa	19.3	20.0	19.1	11.2	11.7	9.9	37.7	32.5	27.1	1.66	1.74	1.70	92.9	137.1	178.3
Western Africa	35.9	44.3	74.0	55.2	87.8	158.9	44.0	67.9	111.0	6.46	8.87	13.57	261.2	293.5	558.0
Africa	189.0	226.6	341.8	176.8	236.6	412.9	207.4	247.0	372.5	17.15	21.67	36.80	907.9	1197.0	1886.3

(FAOSTAT, 2019)

Tab 5: Production of Major Livestock Commodities by Sub-Region

Sub-Region	Cattle Meat			Chicken Meat			Goat Meat			Sheep Meat		
	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17
1000 metric tons												
Eastern Africa	1124.4	1324.4	2264.5	272.3	327.0	666.8	233.1	220.0	403.9	162.5	128.2	290.3
Middle Africa	269.7	344.0	702.6	53.5	59.4	155.3	47.7	74.2	187.1	27.9	34.6	161.8
Southern Africa	710.1	702.5	1142.2	542.3	839.5	1710.1	49.3	23.7	21.0	148.6	121.1	176.8
Western Africa	547.0	728.7	1101.2	311.3	340.1	607.5	222.8	368.3	495.6	146.8	251.1	355.1
SSA	2651.2	3099.7	5210.5	1179.4	1566.0	3139.6	552.9	686.2	1107.6	485.9	534.9	984.0
Africa	3309.8	4010.5	6480.0	1848.8	2780.8	5396.6	658.5	905.4	1341.7	907.0	1240.2	1822.7

Sub-Region	Pig Meat			Whole Fresh Cow's Milk			Hen's Eggs in Shell		
	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17
1000 metric tons									
Eastern Africa	230.4	320.2	590.0	5724.6	7000.5	15561.7	252.3	323.8	489.9
Middle Africa	84.2	88.7	197.6	445.5	531.6	727.9	32.6	37.3	44.8
Southern Africa	137.8	121.7	246.8	2728.8	3077.2	4109.5	217.2	336.3	487.2
Western Africa	173.5	249.1	417.2	1053.1	2030.6	3340.8	458.6	576.0	797.9
SSA	625.8	779.6	1451.7	9952.0	12639.9	23739.9	960.7	1273.5	1819.8
Africa	629.2	783.6	1452.9	15204.2	22014.6	35963.8	1534.5	1962.1	3213.7

(FAOSTAT, 2019)

2.2.3 Dairy Production

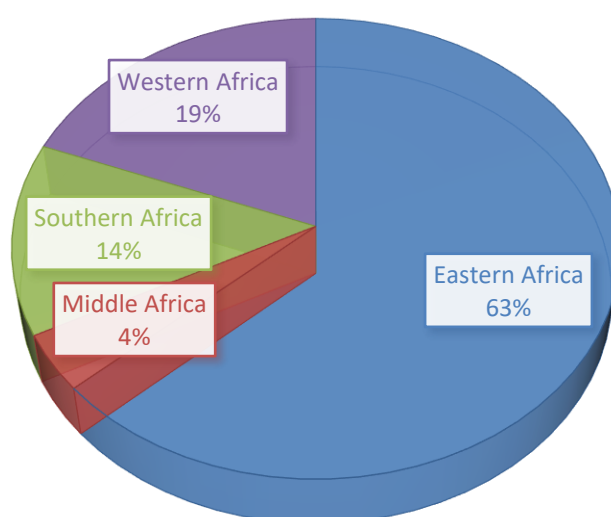
Sub-Saharan dairy production is comprised of cow, camel and small ruminant milk. In the aggregate, cow's milk is the dominant commodity. However, regionally, camel and small ruminant milk play an important role, such as in the Sahel and other drylands (Table 6).

Tab 6: Milk Production by Species and Sub-Region in 2017

Sub-Region	Cow's Milk	Sheep Milk	Goat Milk	Camel Milk	Total Milk	Total Milk Production per Capita
	1000 tons					kg/year
Eastern Africa	15,419	704	1,675	2,012	19,810	48.2
Middle Africa	776	139	269	64	1,247	7.6
Southern Africa	4,194	0	12	0	4,206	64.9
Western Africa	3,633	697	1,139	498	5,967	16.1
SSA	24,022	1,540	3,095	2,573	31,230	30.9

(FAOSTAT, 2019)

Figure 3: Total milk production from cows, sheep, goats and camels in SSA Sub-Region in 2017



Source: FAOSTAT, 2019

Milk production is highly concentrated in Eastern Africa, predominantly in the highlands (Figure 3). Over 60% of total milk output of SSA is produced in this region and mainly by Kenya and Ethiopia. Production has grown markedly over the last decade.

Where environmental conditions are appropriate, dairy production has features that make it particularly attractive as a development pathway. Dairy production generally uses feed resources with low opportunity cost, produces a regular cash flow, employs family labor, and can be efficiently combined with food crop production due to the value of manure for fertilizing crops and the feed value of maize stover, teff straw and other crop by-products. These smallholder dairy systems require access to markets, road infrastructure and farmer organizations. Such structures make it feasible to efficiently provide dairy farmers with services such as artificial insemination, veterinary medicine and access to inputs, finance and insurance. Organizations delivering these services are either governmental, cooperative or led by the private sector.

Besides these intensive smallholder systems, milk is also produced by pastoralists in the drylands mainly for home consumption and within intensive peri-urban systems. The latter rely on ample use of concentrate feed and crop by-products such as cottonseed cake, soybean cake, and cereal brans. Cow milk production can be efficient in hot and dry conditions (e.g. California, Israel) as long as concentrates are available at a low cost. Nevertheless, these systems tend to be quite limited in SSA due to the fact that cereals and sometimes oilseed cakes have high costs. Furthermore, production must compete with imported dairy products from other, more temperate regions of the world. Conditions are particularly unfavorable in the lowland humid tropics because the hot and humid environment is a major stress for cattle in general, particularly for high-producing dairy cows. Furthermore, the disease trypanosomiasis and its carrier, the tsetse fly, form a major production constraint for cattle, sheep and goats in this region. Adapted breeds, such as Ndama cattle and Djalonke sheep, tend to be low producers.

In terms of feed requirements, particularly energy density of the feed, intensive milk production ranges between ruminants fed largely on roughage and monogastrics fed on concentrates. Where rainfall and temperature conditions for higher-quality forages are conducive (e.g. East African Highlands), forages, such as Napier Grass in cut-and-carry-systems, are the predominant feed input into milk production, while peri-urban Sahelian dairy systems rely heavily on concentrates supplemented with low-quality roughage to ensure rumen function.

2.2.4 Feed production

Humans, directly or indirectly, use up 25% of global net primary production (Krausmann et al., 2013). The competing uses of land and biomass are critical to understanding the potential of African livestock production. Besides traditionally producing plant-based food for human consumption, using crops as feed for ruminants and monogastrics plays a major role. Biofuels have become an additional use of biomass.

Biomass is a very heterogeneous material with vastly different chemical structures and seasonality. Humans and monogastric animals both need energy-dense foods and energy in the form of starch and sugar. Ruminants are able to consume feed with lower energy density, with much of the energy in the form of cellulose, that is then degraded and made bioavailable by rumen flora. Typical feeds used are grasses, forages and crop by-products, such as cereal and legume straw. The downsides of the ruminant digestion process are lower conversion efficiency and higher methane production than that produced by monogastric digestion.

Traditional ruminant production systems involve animals harvesting roughage by grazing and browsing for natural vegetation, frequently in combination with the seasonal use of crop by-products and moving animals within the landscape (transhumance and pastoralism). As consumer incomes grow, demand grows and changes in terms of quality demanded. Production systems become more intensive as forages are increasingly intentionally planted for feeding ruminants, stored to overcome seasonal deficits, and then processed and combined with feeds of higher energy density. Other critical nutrients (e.g. minerals) are also added to increase production intensity and output quality as well as to reduce output seasonality. In this context, extensive rangelands can serve as a resource for producing young stock to be finished in more intensive systems. An important side effect of the intensification is a reduction of the GHG emissions intensity per kg of output. This is a major development opportunity: by making it micro-economically attractive for livestock keepers to intensify production, GHG mitigation is achieved by reducing greenhouse gases produced per kg of output. As the population grows and incomes per capita rise, the livestock sector expands and land resources and therefore feed become scarcer. Higher prices for better-quality animal products make the use of higher-quality feed more economical. At this point, major innovations related to feed utilization, forage development, use of dual-purpose crops, feed conservation and additives to balance rations become attractive investment opportunities for farmers themselves, as well as for private-sector suppliers of inputs and services related to the feed sector. Particularly attractive innovations in this field are presented in the next chapter.

2.3 Meat, dairy and feed trade

Sub-Saharan Africa is a major net importer of food and particularly of livestock products and feed for their production (Table 7). Volumes have increased significantly during the last decade. Both meat and live animals are traded within the region and internationally. Trading live animals is particularly important in the Horn of Africa, where there is a long-standing foreign trade with the Gulf States for both cattle and small ruminants.

Exporting live animals is important in most of Sub-Saharan Africa, which is reflected by the reality of consumer preferences. For instance, live fat-tailed sheep are exported from the Horn of Africa to Gulf states to be slaughtered at their destination markets using Halal procedures. In terms of stock numbers, Eastern Africa's small ruminant exports are much larger than cattle exports, but in terms of value, these three exported species mentioned are similar. Additionally, there is an important traditional trade from the Sahel countries to the coastal regions of West Africa (Table 8).

The SSA region as a whole is a large net importer of dairy products (Table 9). Southern Africa has the smallest deficit, while Western Africa is the largest net importer. The biggest trading partner of Africa for animal products is the European Union. European trade and agriculture policies are significant determinants of this growing trade (Kornher and von Braun, 2020).

Tab 7: Net Trade in Major Meat Types by Sub-Region and Volume

Sub-Region	Volume of Total Meat			Volume of Bovine Meat			Volume of Poultry Meat		
	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17
1000 metric tons									
Eastern Africa	8,122	5,773	81,246	-667	-3,116	15,812	3,776	4,076	66,558
Middle Africa	108,003	180,429	866,100	48,090	49,011	98,744	48,692	103,749	603,051
Southern Africa	18,578	133,243	368,698	-11,518	-37,839	-69,608	30,872	106,422	417,908
Western Africa	88,731	115,175	521,747	65,880	14,023	26,164	17,631	93,527	435,096
SSA	223,434	434,620	1,837,791	101,785	22,079	71,112	100,971	307,774	1,522,613
Africa	383,117	659,468	2,436,771	252,345	237,780	485,909	101,934	313,231	1,701,801

Sub-Region	Value of Total Meat			Value of Bovine Meat			Value of Poultry Meat		
	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17
1000 US\$									
Eastern Africa	15,978	17,596	109,747	-2,487	5,466	56,097	6,579	5,044	80,272
Middle Africa	167,928	201,150	1,142,686	75,844	50,330	233,200	62,250	113,628	640,729
Southern Africa	-41,622	-31,703	125,614	-68,235	-106,856	-235,310	27,777	53,763	322,224
Western Africa	83,528	84,666	538,466	56,336	13,574	37,997	17,642	61,229	436,343
SSA	225,812	271,709	1,916,514	61,458	-37,486	91,984	114,248	233,664	1,479,567
Africa	448,264	555,377	3,684,456	270,033	239,330	1,544,530	116,049	241,682	1,770,019

Imports= positive values, Exports= negative values
(FAOSTAT, 2019)

Tab 8: Exports of Live Animals by Sub-Region

Sub-Region	Export Volume								
	Cattle			Goats			Sheep		
	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17
	1000 heads								
Eastern Africa	131	127	315	340	678	2272	340	1542	2310
Middle Africa	88	138	127	80	100	110	90	24	0
Southern Africa	148	31	254	0	30	197	858	240	453
Western Africa	454	605	392	468	887	427	762	968	572
SSA	820	902	1088	889	1694	3007	2050	2774	3334
Africa	834	902	1099	935	1700	3307	2701	3357	7622

Sub-Region	Export Value								
	Cattle			Goats			Sheep		
	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17
	million US\$								
Eastern Africa	22	34	173	17	19	199	16	46	205
Middle Africa	37	51	45	4	8	9	4	2	0
Southern Africa	44	8	122	0	1	9	38	7	24
Western Africa	122	144	129	17	25	16	38	31	41
SSA	225	236	469	38	53	233	96	86	270
Africa	233	236	486	40	53	250	174	130	713

(FAOSTAT, 2019)

Tab 9: Net Imports of Milk Equivalents by Sub-Region

Sub-Region	Volume of Net Imports			Value of Net Imports		
	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17
	1000 metric tons			1000 US\$		
Eastern Africa	301,113	278,117	666,421	92,751	101,814	384,770
Middle Africa	276,444	203,844	575,580	120,432	76,958	322,723
Southern Africa	14,119	279,256	88,204	15,213	74,050	64,745
Western Africa	803,912	1,008,386	2,077,522	275,360	307,216	805,090
SSA	1,395,588	1,769,603	3,407,726	503,756	560,038	1,577,328
Africa	4,503,482	4,493,478	8,347,550	1,420,053	1,294,648	3,608,137

(FAOSTAT, 2019)

In low-income countries, per-capita consumption of animal-source foods tends to be low with plant-based food predominating the diet. This leads to a relatively low domestic demand for crop by-products that are not directly edible by humans, such as certain cakes from the extraction of vegetable oils (e.g. sesame, palm oil kernel, soybean, cotton seed cake) or cereal byproducts such as brans. These are valuable sources of protein and sometimes energy for feeding monogastric animals as well as intensively managed ruminants such as high-yielding dairy cows or finishing cattle and small

ruminants. There is therefore an active trade in these feedstuffs from lower-income countries to higher-income countries, where demand for animal-source foods is higher.

Table 10 shows that since 1990, SSA has shifted from being a net exporter of feeds to becoming an increasingly important importer of animal feed. Among the subregions, Southern Africa is the largest net importer in terms of both volumes and values. This is in line with the high per-capita levels of monogastric meat and eggs as well as milk consumed in Southern Africa. Western Africa has historically been the largest animal-feed exporting region of SSA, which has been significantly driven by cotton and groundnut production and the associated trade in cottonseed and groundnut cake. Given the growth in demand of animal products, the sub-region has now reduced its net exports in terms of volume and has remained a net exporter of about US\$ 50 million p.a.

Tab 10: Net Trade in Fodder and Feeding Stuff by Sub-Region

Sub-Region	Volume of Net Trade			Value of Net Trade		
	1990	2000	Avg 2015-17	1990	2000	Avg 2015-17
	1000 metric tons			1000 US\$		
Eastern Africa	-3,030	-34,166	-311,636	8,288	-1,024	4,125
Middle Africa	-827	-8,658	29,007	13,090	9,168	58,062
Southern Africa	70,508	745,499	764,349	23,406	138,004	278,396
Western Africa	-512,787	-557,860	-168,888	-53,327	-50,467	-50,592
SSA	-446,136	144,815	312,831	-8,543	95,681	289,991

Imports= positive values, Exports= negative values
(FAOSTAT, 2019)

2.4 Livestock production systems and associated livelihoods

Livestock have the capacity to utilize natural resources with low opportunity cost by grazing on drylands and feeding on straw and other biomass not directly consumed by humans and convert them into high value products such as meat and milk. This makes livestock production, particularly ruminant livestock, attractive for the poor. Globally, it is estimated that about 70% of the world's 1.4 billion extreme poor depend in one way or another on livestock (FAO, 2009). However, as the pressure on land use grows, with more grazing land converted to crops the opportunity cost of rangeland is increasing.

Livestock production in SSA functions largely as a circular system. Mixed crop-livestock-tree systems enable livestock to provide traction for land preparation and transportation. Manure constitutes an important source of nutrients to maintain soil fertility. For poor livestock keepers, animals fulfill a number of functions: as a source of highly available nutrients in their diets; income sources; opportunity to use family labor; wealth accumulation, particularly for people without access to banking services and without other profitable investing opportunities; insurance function; and so on. Livestock is particularly important for women, because in many societies land is controlled by men, however women can own animals and control this resource. This is particularly the case for small ruminants and poultry (Nyuki and Sanginga, 2013).

Policy interventions in developed countries' livestock sector largely operate on the premise that farmers keep livestock in order to earn an income from their production for the market. In SSA, the multiple roles of livestock, the complex interplay of livestock keeping and the natural resources as well as the agroecological and socioeconomic context make it imperative to understand this multifunctionality to design effective interventions.

This need has led to a long-standing tradition of farming systems and livestock systems research that seek to understand these relationships and develop typologies of such systems. Originally, they emphasized farm-level systemic relationships. Over time, as developing economies have become more market-oriented, systems perspectives have gone beyond the farm gate to consider value chains, non-agricultural income sources and employment, gender dimensions, ecosystem services and, more recently, broader landscape and food system perspectives.

The livestock systems typology largely builds on the source of the feed (grazing versus mixed crop livestock systems), the contribution of livestock versus crops to income and the length of the growing period based on climatic conditions (drylands, humid or temperate/highland).

This study follows the livestock systems classification by Robinson et al. (2011):

- livestock only, grassland-based, arid and semi-arid (LGA)
- livestock only, grassland-based, humid and sub-humid (LGH)
- livestock only, grassland-based, temperate and highland (LGT)
- mixed rainfed arid and semi-arid (MRA)
- mixed rainfed humid and sub-humid (MRH)
- mixed rainfed temperate and highland (MRT)
- mixed irrigated arid and semi-arid (MIA)
- mixed irrigated humid and sub-humid (MIH)
- mixed irrigated temperate and highlands (MIT)
- Other residual, mainly forest environments
- Urban

Robinson et al. (2011) mapped these systems world-wide and overlaid this spatial information with estimates on stock numbers, thereby allocating stocks to specific farming systems within SSA sub-regions. It should be noted that monogastric animals (poultry and pigs) are not included in their analysis (see Figure 4).

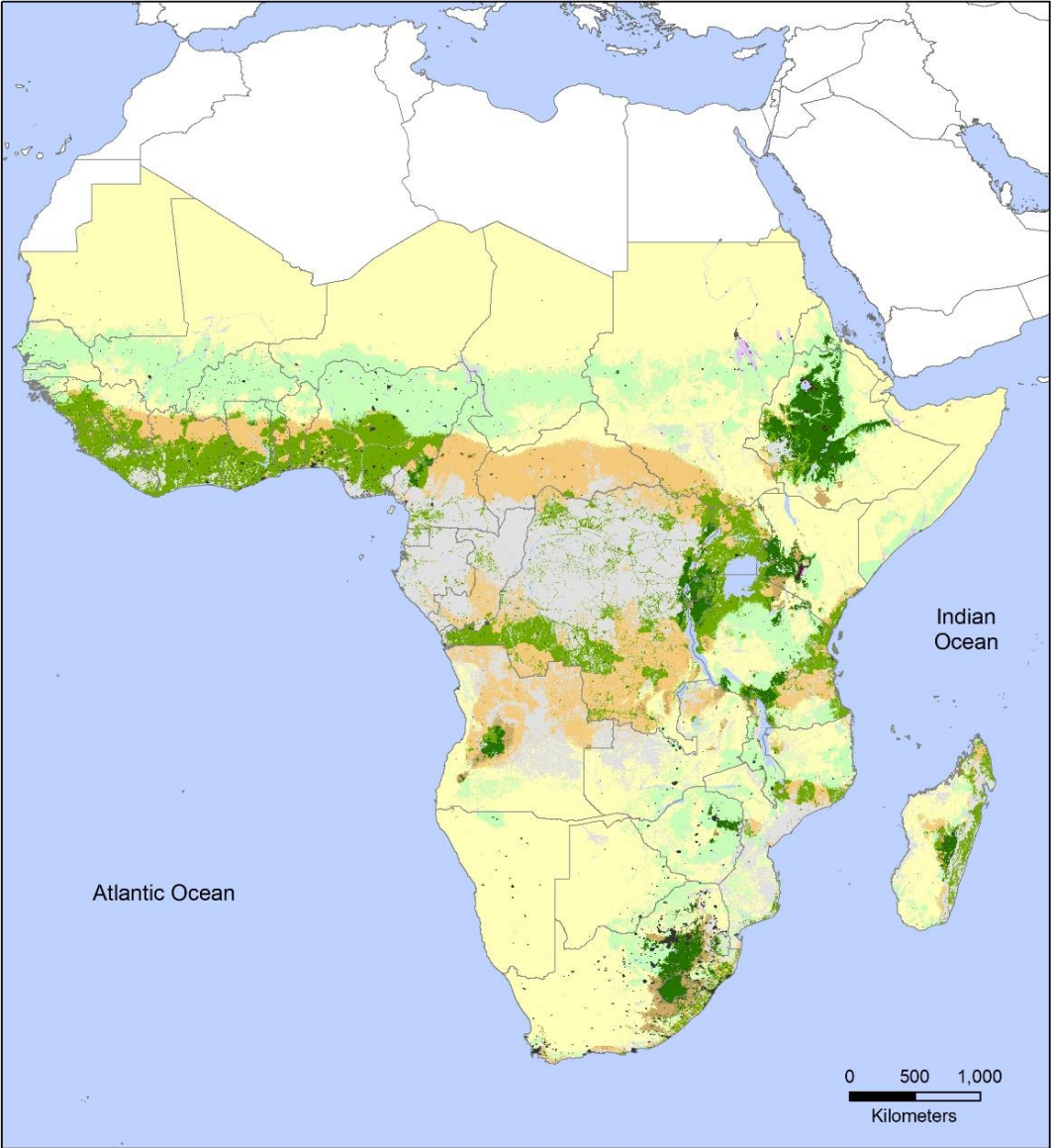
The bulk of SSA's cattle are found in mixed systems, with the largest numbers located in mixed arid and semi-arid systems (Table 11). Eastern Africa has the largest number of cattle among SSA sub-regions, which are concentrated in the highlands mixed systems (MRT). Western Africa has the second largest cattle inventory, which are concentrated in both livestock only and mixed systems in arid and semi-arid regions. The category "other" represents largely forested areas. In relative terms, the importance of this system is particularly high in Middle Africa, a region that, in absolute terms, has low numbers of cattle.

Goat numbers follow a pattern similar to that of cattle distribution, but with a higher concentration in arid and semiarid systems. There is also an important number of goats in the forest systems of Middle Africa.

Sheep are particularly prevalent in Western Africa, in both livestock only and mixed systems in arid and semiarid regions. Important sheep clusters are also found in mixed systems in the Eastern African Highlands and in the livestock-only systems of the Eastern and Southern African drylands.

To aggregate the total ruminant livestock biomass stocks of different ruminant species, they are converted into Tropical Livestock Units (TLU), where one head of cattle equals 0.7 TLU, while one sheep or goat equals 0.1 TLU. As Table 12 shows, mixed crop-livestock systems are home to the largest number of TLUs, followed by livestock-only systems in arid and semiarid regions. Eastern Africa contains more than half the total SSA stock of TLUs, followed by Western Africa. Middle and Southern Africa each comprise less than 10% of the SSA total.

Figure 4: Livestock production systems



 LGA	 MRA	 MIA	 Urban areas
 LGH	 MRH	 MIH	 Other
 LGT	 MRT	 MIT	

Source: Reproduced from Robinson et al., 2011

Tab 11: Cattle Stock Numbers by Farming System and Sub-Region of SSA

Farming system		Eastern Africa	Middle Africa	Southern Africa	Western Africa	SSA
		1000 head				
Livestock only, grassland-based, arid and semi-arid	LGA	21,016	5,755	7,624	14,780	49,175
Livestock only, grassland-based, humid and sub-humid	LGH	2,634	3,860	399	1,923	8,815
Livestock only, grassland-based, temperate and highland	LGT	1,249	379	2,657	0	4,285
Mixed rainfed arid and semi-arid	MRA	25,118	4,473	3,562	33,510	66,664
Mixed rainfed humid and sub-humid	MRH	18,354	373	720	4,894	24,341
Mixed rainfed temperate and highland	MRT	43,529	206	2,538	30	46,303
Mixed irrigated arid and semi-arid	MIA	701	8	96	647	1,451
Mixed irrigated humid and sub-humid	MIH	168	1	13	27	210
Mixed irrigated temperate and highlands	MIT	1,088	0	40	0	1,128
Other residual, mainly forest environments	Other	12,803	5,230	1,467	3,581	23,081
Urban	Urban	2,201	88	865	817	3,971
Total cattle stock number		128,861	20,373	19,981	60,209	229,424

(Robinson et al., 2011)

Tab 12: Stock of Ruminant Tropical Livestock Units (TLUs)* by Farming System and Sub-Region of SSA

Farming system		Eastern Africa	Middle Africa	Southern Africa	Western Africa	SSA
		1000s				
Livestock only, grassland-based, arid and semi-arid	LGA	20,838	4,696	7,189	15,307	48,030
Livestock only, grassland-based, humid and sub-humid	LGH	1,982	3,235	341	1,715	7,273
Livestock only, grassland-based, temperate and highland	LGT	1,072	290	2,228	0	3,590
Mixed rainfed arid and semi-arid	MRA	20,466	3,600	2,935	34,879	61,880
Mixed rainfed humid and sub-humid	MRH	14,554	354	563	5,308	20,779
Mixed rainfed temperate and highland	MRT	33,703	195	2,244	26	36,169
Mixed irrigated arid and semi-arid	MIA	573	6	81	663	1,323
Mixed irrigated humid and sub-humid	MIH	132	1	11	30	174
Mixed irrigated temperate and highlands	MIT	824	0	32	0	856
Other residual, mainly forest environments	Other	11,519	5,031	1,501	4,453	22,505
Urban	Urban	1,807	94	727	1,107	3,735
Total TLUs		107,471	17,503	17,852	63,488	206,313

Tropical Livestock Units (TLU)
 1 head of cattle = 0.7 TLU, 1 sheep or goat = 0.1 TLU
 (Author's own calculations based on Robinson et al., 2011)

Tab 13: Number of Poor* Livestock Keepers by Farming System and Sub-Region of SSA

Farming system		Eastern Africa	Middle Africa	Southern Africa	Western Africa	SSA
		1000s				
Livestock only, grassland-based, arid and semi-arid	LGA	7902	2016	659	3926	14503
Livestock only, grassland-based, humid and sub-humid	LGH	1272	4121	20	1641	7054
Livestock only, grassland-based, temperate and highland	LGT	279	163	89	1	531
Mixed rainfed arid and semi-arid	MRA	21649	2594	1530	26501	52274
Mixed rainfed humid and sub-humid	MRH	20828	4831	756	22790	49205
Mixed rainfed temperate and highland	MRT	22972	1441	1005	54	25472
Mixed irrigated arid and semi-arid	MIA	153	2	12	120	287
Mixed irrigated humid and sub-humid	MIH	94	2	3	41	139
Mixed irrigated temperate and highlands	MIT	156	0	2	0	159
Other residual, mainly forest environments	Other	4526	4564	186	1621	10898
Total number of poor livestock keepers		79832	19734	4261	56696	160522
Livestock only, grassland-based, arid and semi-arid	LGA	7902	2016	659	3926	14503

* International poverty rate US\$ 1.25 per day
(Robinson et al., 2011)

Robinson et al. (2011) estimated the numbers of poor livestock keepers by country and production system. These numbers consider only keepers of ruminant animals, who are more closely associated with mapped natural resources. Monogastric systems (not included in Robinson's analysis) are driven more by markets and human populations than by land resources.

In spite of their methodological limitations, these numbers provide a plausible estimate of the number of poor livestock keepers by country and production system (see Table 13). The distribution of poor livestock keepers broadly aligns with the presence of ruminant TLUs, with Eastern Africa being home to 50% of the total SSA figure, followed by Western Africa. Middle and Southern Africa have largely similar numbers of TLUs, however Middle Africa has more than four times the number of poor livestock keepers as compared to Southern Africa. This reflects the higher per-capita GDP of Southern Africa.

Poor livestock keepers are highly concentrated in mixed crop-livestock systems. In contrast to regions of South Asia, very little livestock as well as poor livestock keepers are found in irrigated systems in SSA. On the other hand, arid and semiarid regions in SSA have high TLU numbers, but lower concentrations of poor livestock keepers. These clusters of the poor are nevertheless highly dependent on livestock as opposed to those in mixed systems.

2.5 Animal health and veterinary services

In Sub-Saharan Africa, domesticated livestock, wildlife and humans have co-evolved over a long period. Their pests and diseases have evolved with them. Animal health issues associated with the environmental conditions have proven to be a serious limiting factor for the intensification of animal production. This co-evolution has led to the development of animal genotypes that are resistant or tolerant of major pests and diseases, but that also tend to be of limited productivity. Serious animal health concerns are tsetse flies and trypanosomiasis as well as ticks and tick-borne diseases. The control and eradication of tsetse flies from Africa has been an important step forward, involving approaches from destruction of the host vegetation to large-scale spraying of insecticides to the use of pour-on insecticides to the massive release of sterile male flies. Over time, population growth and the associated clearing of land for agriculture have somewhat reduced the problem. Nevertheless, tsetse flies and trypanosomiasis are still a major limiting factor, particularly in humid areas of equatorial Africa. It has been argued that the tsetse fly problem has protected the Congo basin from being cleared for livestock production like the Amazon.

The control of ticks and tick-borne diseases is particularly challenging in SSA due to the diversity of tick species prevalent in the region and the various diseases they transmit. This issue has been addressed with acaricides and dipping or spraying.

In the course of the policy changes associated with the Washington Consensus,¹ public veterinary services were reduced, and the private sector was expected to take over a large part of their functions, particularly those that have private-good character. Given the low number of veterinarians in SSA, one solution explored was to empower community animal health workers to perform many of the functions delivered by veterinarians in developed economies. This has been a very contentious issue due to some extent to corporative interests of the veterinary profession.

The challenge of implementing economically viable models for the delivery of animal health/veterinary services to pastoralists and smallholder livestock keepers in SSA is substantial.

¹ The Washington Consensus was a set of policies promoted by the World Bank, the International Monetary Fund and the US Treasury to enhance growth in developing countries by promoting the role of free markets. Policies included the privatization of public services, free trade, flexible exchange rates, and low government borrowing, among others.

Developed country approaches frequently do not work due to the limited enforcement capacity of governments and the multiple roles of livestock for impoverished livestock keepers. These create complex incentives and disincentives for dealing with animal health problems (Randolph, 2019). This context has led to a strong emphasis on preventive veterinary medicine and, particularly, the development of vaccines. The eradication of rinderpest is a classic success case of the use of vaccines to eradicate a disease.

Another further development has been the One Health concept. It addresses the fact that many diseases are zoonoses that are shared by humans and domestic animals; this particularly affects poor livestock keepers. Until recently, the medical profession would tackle the medical aspects while vets would independently address the problem in the animal population. It has been recognized that zoonoses require a holistic approach that deals with humans and animals simultaneously. Good examples of settings, where the One Health approach is particularly relevant, are the control of tuberculosis, brucellosis, and cysticercosis, among others.

The rapid globalization of trade and the increased movement of people across the globe have added a further dimension to the role of public veterinary services. Many diseases cross national borders. The management of global public bads requires national veterinary services to be capable of doing their part within the global infrastructure to deal with these issues, in particular the World Health Organization, the Food and Agriculture Organization and the World Organization for Animal Health OIE (Office International des Epizooties). The case of Avian Flu and the recent spread of African Swine Fever to China highlight the global nature of many disease issues. This global dimension is exacerbated by climate change, which enables pests and diseases to spread into new regions.

The above-described situation of animal health and veterinary services in Sub-Saharan Africa documents the difficulties many countries face to run fit-for-purpose public veterinary services. OIE keeps statistics on veterinarians working in the public sector: in 2017, countries in SSA reported a range of 1867 veterinarians in Nigeria down to 1 veterinarian in Gambia. The median value was 71. For comparison, Germany reported 1400 veterinarians working in the public sector (OIE WAHIS, 2020). This comparison highlights the challenges and the need to develop innovative ways of delivering these services throughout SSA.

2.6 Livestock and climate change

Livestock represent an important source of GHG emissions in SSA. CAIT/WRI (2016) estimates the total anthropogenic GHG emissions of SSA at 3815.3 Mt CO₂ eq. and the share of agriculture at 24% thereof. FAOSTAT (2016) estimates that livestock produces 70% of the total GHG emissions of SSA agriculture. Combining both computations (based on somewhat different methodologies), it is estimated that livestock emit approximately 17% of the total GHG emissions of SSA. The amount is driven by the stock numbers and high emission intensity of ruminants fed on low-quality diets. By intensifying their ruminant production and improving rangeland management, livestock keepers can earn a higher return and at the same time reduce GHG emission intensity (Thornton and Herrero, 2010).

In the Paris Agreement on Climate Change, countries committed to provide inventories and Nationally Defined Contributions (NDCs) to reduce GHG emissions. The computation of these inventories for the livestock sector was initially done using standard global coefficients per head (Tier 1 calculations). It was recognized that emissions intensity varies widely across breeds and livestock feeding systems. Thus, to be able to compute changes in GHG emissions beyond changes in stock numbers, more estimates of emission intensity disaggregated by livestock system, feeding intensity, etc. (Tier 2 estimates) are required. Most African countries have not yet established Tier 2 inventories due to a lack of data on emissions coefficients reflecting their national livestock production systems.

Given the scale of ruminant livestock production in SSA and the associated rangelands, intensification of production per animal would reduce the GHG emissions intensity per kg of output, thereby creating massive reductions for a given level of output produced. Similarly, improvements in range management could increase carbon sequestration. Even though per hectare amounts would be low given the vast areas involved, the amounts could be significant in absolute terms. Innovations leading to increased intensity of production and improved range management would thus provide important co-benefits in terms of GHG emissions. Therefore, a key issue is whether CO₂-emissions trading or other mechanisms could be established to compensate African countries for these livestock-related mitigation contributions. Such payments would increase the profitability of the adoption of the above-described innovations.

Some modeling exercises point to the fact that parts of Africa presently engaged in mixed crop-livestock systems would, under climate change scenarios, lose their competitiveness in crop production and shift to pastoral livestock systems. Thus, one plausible path of adaptation to climate change could imply an expansion of areas in pastoral production (Jones and Thornton, 2009).

A further trade-off is related to the cost of fuel for transportation. Policies increasing the cost of fossil fuels would reduce oil consumption for transport and increase the cost of transportation. This penalizes remote regions and reduces the profitability of intensifying livestock production in those regions. Particularly in land-locked countries, high transport costs will protect domestic production vis-à-vis imports from other continents (e.g. Brazil, USA, EU).

Monogastric animals (poultry and pigs) have a lower GHG emission intensity per kg of meat produced. Thus, shifting consumption from ruminant meat to monogastric meat can reduce GHG emissions. The trade-off is nevertheless related to the fact that efficient poultry production (beyond the household-level scavenging poultry systems) requires the feeding of concentrates. These are based on crops (cereals, oilseeds) that can be consumed by humans directly. Their production requires land and inputs or foreign exchange to pay for imports.

In summary, climate change considerations are central to design a food security strategy and, within it, the role of different livestock systems and species/commodities. Holistic approaches are needed to address the multiple trade-offs and co-benefits. The complexity of the issues involved justifies addressing them through international cooperation within Africa and beyond.

3 Potential for Sustainable Livestock Development in Sub-Saharan Africa: A Cross-Country Comparison

3.1 The conceptual model

Under the IFPRI IMPACT model (Robinson et al., 2015), the potential growth of the livestock sector of individual countries in SSA is simulated up to 2030 using a scenario of modest climate change. This exercise allows for a simultaneous consideration of supply and demand of individual commodities as well as trade aspects. The change in domestic production between 2010 and 2030 is considered a proxy for “potential.” The IMPACT model used is a global partial equilibrium model depicting the markets for 60 commodities (food and cash crops) for 159 countries. The specific information on the simulation of the African livestock sector used here is provided by Enahoro et al. (2019).

The estimates are based on scenario SSP2_HGEM_RCP_6.0_CO2_379. This scenario uses a shared socio-economic pathway (SSP) of middle-of-the-road, i.e. moderate growth in the global economy and population to 2050; it assumes climate change effects of Representative Concentration Pathway (RCP) 6.0 ppm as simulated in the Hadley Center’s Global Environment model, version 2.² Robinson et al. (2015) explain why structural models like IMPACT are difficult to validate against historical data. These long-term models show average tendencies and cannot reflect short-term shocks. The current COVID-19 pandemic is such a case of disruption of economic development and growth. It may be assumed that demand for animal products is sharply reduced during the crisis but will probably recover thereafter. Further implications of the pandemic for the SSA livestock sector are presented in Chapter 5.

The fact that the IMPACT model does not explicitly take into account rangelands as feed resource for ruminants is a further caveat. In the model herd expansion is driven exogenously by growth rates reflecting past trends, which do not account for possible deviations driven by climate change or increasing natural resource constraints (Enahoro, personal communication).

The production levels forecast by the model synthetically express the interplay of supply and demand elasticities, population and income levels and their respective growth rates, and the effects of international trade. They are thus considered plausible 2030 scenarios. This “potential” can be expressed in terms of the absolute increase in production as well as in the annual growth rate of production. Both dimensions are of relevance to policy and investment decisions:

- Larger absolute increases in production point to significant impacts on national and regional food security, nutrition, environment and employment.
- Higher annual growth rates of production point toward situations of rapid change and consequent merit of addressing technology, information, capacity building and similar interventions “lubricating” change.
- Situations of simultaneous high absolute increases in production and high annual growth rates are particularly important given the interplay of both effects.

This information is presented in scatterplots that show the distribution of individual countries in SSA across the dimensions of absolute production increments versus annual growth rates of production of the respective livestock commodity. The analysis includes 39 countries listed in Annex 2. The quadrant boundaries are set at the median value for the incremental output of each commodity (2010 to 2030) and at the forecasted growth rate of the population of SSA for the period 2020 to 2030 with a value of 2.5% p.a. This value was chosen to showcase in which countries production can be expected

² In the IPCC’s fifth Assessment Report, Representative Concentration Pathways (RCP) were used as a greenhouse gas concentration (not emissions) trajectory (IPCC, 2014).

to grow faster than the population, a situation thus making possible increased production per capita and either increased consumption, reduced imports, increased exports or a combination of the above.

The scatterplots thus have four quadrants reflecting different combinations of volume and growth rate:

Q 1: high incremental volume, low growth rate (NW quadrant)

Q 2: high incremental volume, high growth rate (NE quadrant)

Q 3: low incremental volume, low growth rate (SW quadrant)

Q 4: low incremental volume, high growth rate (SE quadrant)

Building on these scatterplots, a synthesis of “livestock development potential” is attempted by identifying countries that score in the “high incremental volume, high growth rate” quadrant in two or more of the analyzed commodities. This group of countries can be expected to play a key role in shaping the region’s handling of the multiple livestock development issues in the coming decades.

3.2 Model findings

The results of the simulation are presented for ruminant meat (cattle, sheep, goats), monogastric meat (poultry, pork) and milk to reflect the different resource requirements of these three groups of livestock production systems. Model results are presented in tabular form and aggregated by sub-region. The model estimates that ruminant meat production in SSA would grow from 5,835,000 MT in 2010 to 10,707,000 MT in 2030. Monogastric meat production in SSA is forecasted to grow from 3,257,000 MT to 6,179,000 MT (Table 14). Milk production would grow from 17 million MT in 2010 to 27 million MT in 2030 (Table 15).

Western Africa is the region with the highest expected growth rates of both ruminant and monogastric production, while Southern Africa, with more developed markets, higher incomes and higher levels of per-capita consumption, shows the lowest growth rates for both types of meats. The share of monogastric meat out of the total meat produced for SSA grows marginally from 35.8 to 36.6%. Important differences exist among subregions. Eastern Africa contains the lowest share of monogastric meat (27%) in 2010 and would remain at this level in 2030. Southern Africa has the highest share of monogastric meat with 53% in 2010, growing slightly to 55% in 2030. The largest percentage point increase is observed in Middle Africa, going from 31% to 35% in 2030. This confirms that given SSA’s resource endowment, ruminant meat production will continue to be the most important source of animal protein. Nevertheless, monogastric meat production is expected to grow faster than ruminant meat, thereby increasing in importance in SSA, but doing so at a slower rate than what has been historically observed in other developing regions.

Tab 14: Estimated Meat Production Increase from 2010 to 2030 by Meat Type and Sub-Region

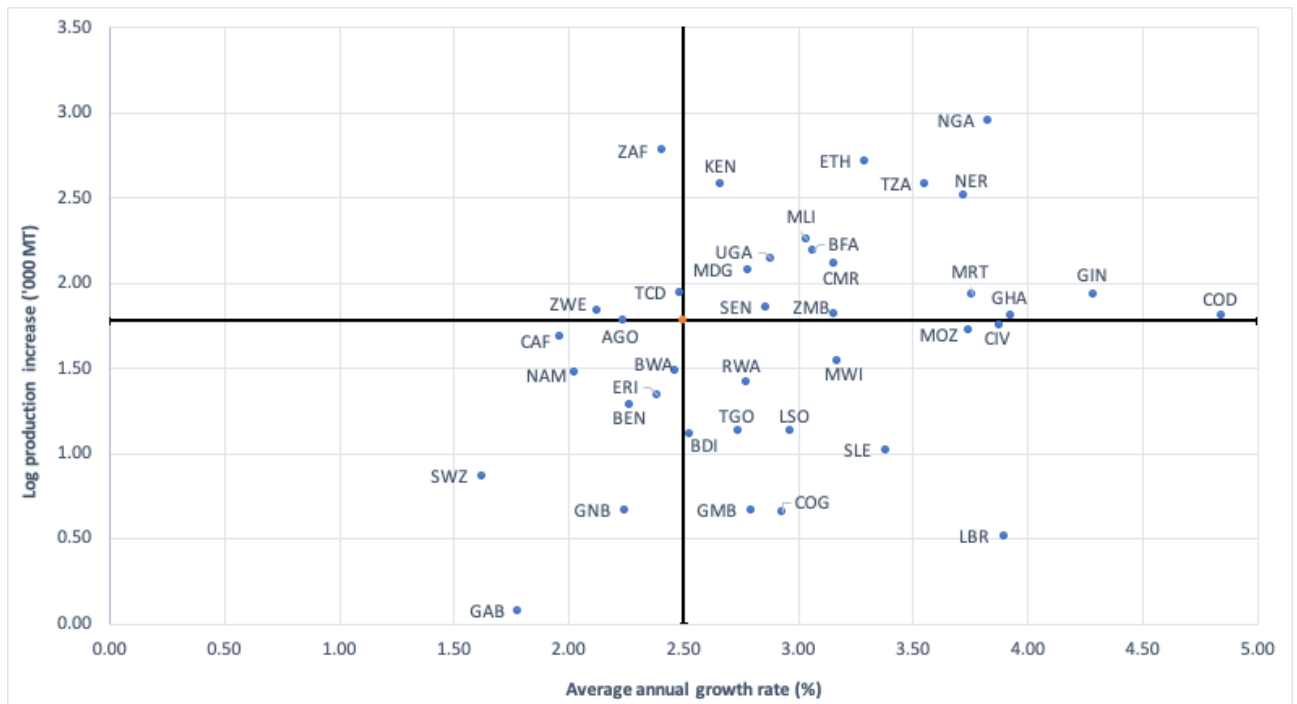
Sub-Region	Ruminant Meat Production				Monogastric Meat Production				Total Meat Production			
	2010	2030	Change between 2010-30	Avg annual growth rate	2010	2030	Change between 2010-30	Avg annual growth rate	2010	2030	Change between 2010-30	Avg annual growth rate
	'000 MT	'000 MT	'000 MT	%	'000 MT	'000 MT	'000 MT	%	'000 MT	'000 MT	'000 MT	%
Eastern Africa	2228	4048	1820	3.03	835	1534	699	3.09	3063	5583	2519	3.05
Middle Africa	547	942	395	2.76	246	510	265	3.72	792	1452	660	3.08
Southern Africa	1126	1805	679	2.39	1274	2219	945	2.81	2400	4024	1624	2.62
Western Africa	1934	3911	1977	3.58	902	1916	1014	3.84	2836	5827	2991	3.67
SSA	5835	10707	4871	3.08	3257	6179	2922	3.25	9092	16886	7794	3.14

(IMPACT model estimates)

The ruminant meat scatterplot (Figure 5) shows that a number of countries across all sub-regions can be expected to grow at annual rates beyond the region’s expected population growth rate. The model expects most countries to be net importers by 2030. It also foresees that very few countries in SSA will be significant net exporters of ruminant meat. The largest are Ethiopia and South Africa, followed by Namibia, Botswana and Cameroon with minor volumes of net exports from Mauritania, Eritrea and Guinea. The model forecasts that net exports will be concentrated in Ethiopia and Southern Africa with net exports from Western African countries declining from 2010 to 2030 (see Annex 2).

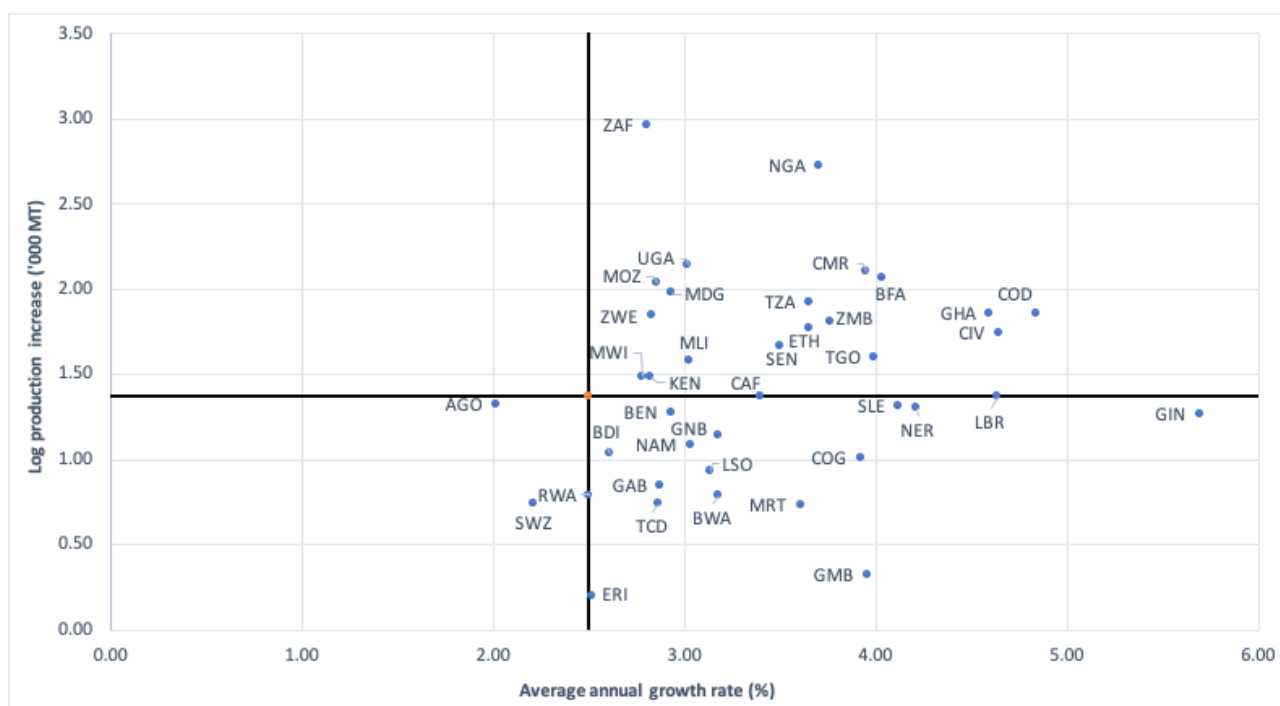
The monogastric meat scatterplot (Figure 6) shows that, even by 2030, monogastric meat production in SSA would be lower than ruminant meat production. Countries cluster at lower levels of production increase. At the same time, the scatterplot shows a larger number of countries in the NE and SE quadrants (growth rates higher than 2.5% pa). The simulation projects only limited net exports of monogastric meat from SSA by 2030 (mostly from Cameroon and Zimbabwe). Given the fact that most countries were net importers in 2010 and are expected to expand their production at rates above that of the population (2.5%), they should be able to increase per-capita consumption, reduce the share of net imports or pursue a combination of both options.

Figure 5: Ruminant Meat Production: Projection of Absolute Production Increase versus Average Annual Production Growth Rate (2010-2030)



Source: Author computation based on Enahoro et al., 2019

Figure 6: Monogastric Meat Production: Projection of Absolute Production Increase versus Average Annual Production Growth Rate (2010-2030)



Source: Author computation based on Enahoro et al., 2019

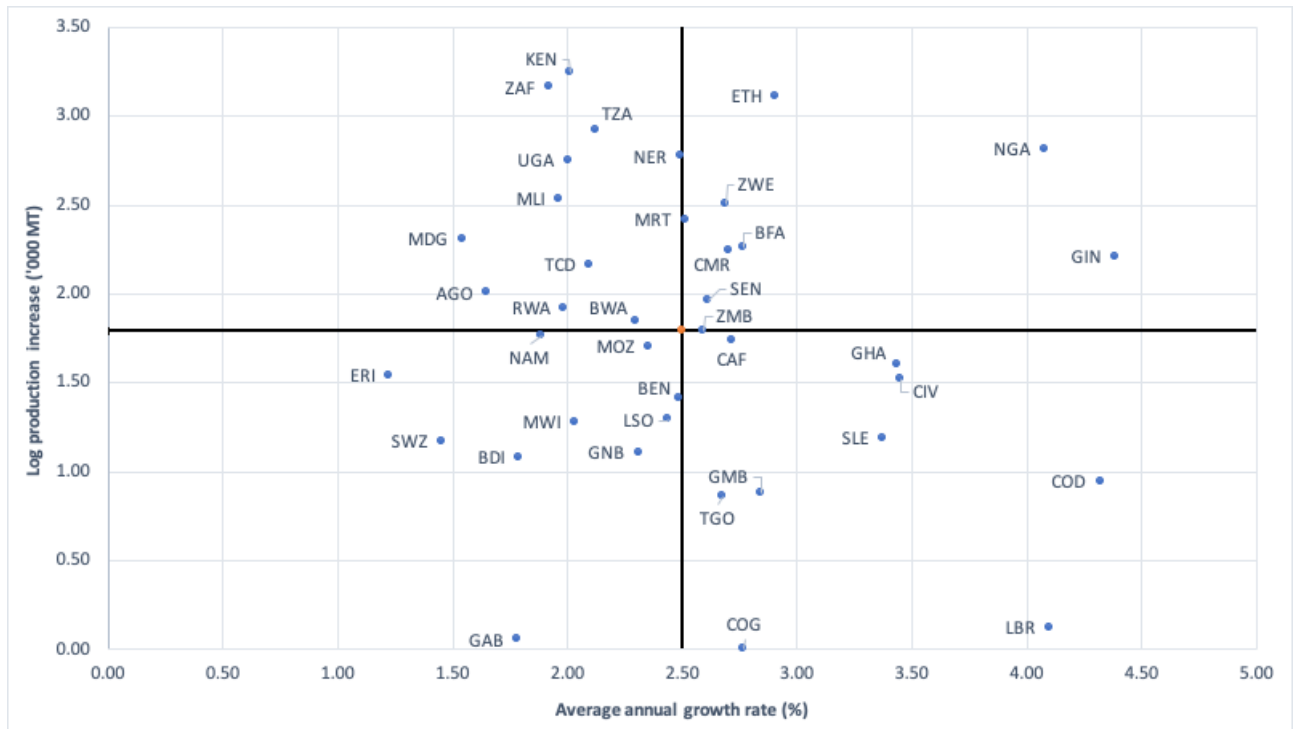
Dairy production is expected to grow at a lower rate than other commodities and at rates below that of regional population growth, thus implying that per-capita production will decline causing a reduction in per-capita consumption or an increase in imports or a combination of both. Highland countries in Eastern Africa offer the most favorable conditions for dairy production, as shown by the expected increase in volume. The scatterplot (Figure 7) shows that besides East African countries, only a few other countries play an important role in milk production in SSA. Notable cases include Nigeria, Niger and Mali in West Africa and South Africa and Zimbabwe in Southern Africa.

Tab 15: Estimated Milk Production Increase from 2010 to 2030 by Sub-Region

Sub-Region	Milk Production			
	2010	2030	Change between 2010-30	Average annual growth rate
	'000 MT	'000 MT	'000 MT	%
Eastern Africa	9598	14841	5243	2.20
Middle Africa	879	1366	487	2.23
Southern Africa	3446	5055	1609	1.93
Western Africa	3257	5675	2418	2.82
SSA	17180	26937	9757	2.27

(IMPACT model estimates)

Figure 7: Milk Production: Projection of Absolute Production Increase versus Average Annual Production Growth Rate (2010-2030)



Source: Author computation based on Enahoro et al., 2019

Livestock production in SSA has performed quite successfully in terms of livestock development during the 21st century (Tables 4 and 5) and model projections imply there is a high probability of it continuing to grow rapidly until 2030. Nevertheless, the ongoing COVID-19 pandemic may reverse years of poverty reduction (see also Chapter 5.2). When jointly analyzing the scatterplots for the three main livestock commodities, six countries (Burkina Faso, Cameroon, Ethiopia, Nigeria, Senegal, Zambia) can be located within the “high growth, high volume” quarter in all three scatterplots (ruminant meat, monogastric meat, milk) (Table 16). These “leading African livestock producers” as a group are expected to produce 38% of the SSA total of ruminant meat, 32% of monogastric meat and 20% of milk by 2030.

Tab 16: High Potential Countries in Ruminant, Monogastric Meat and Milk Production

Country		Ruminant Meat Production	Monogastric Meat Production	Milk Production	Total Score
Burkina Faso	BFA	*	*	*	***
Cameroon	CMR	*	*	*	***
Ethiopia	ETH	*	*	*	***
Nigeria	NGA	*	*	*	***
Senegal	SEN	*	*	*	***
Zambia	ZMB	*	*	*	***
DRC	COD	*	*		**
Ghana	GHA	*	*		**
Guinea	GIN	*		*	**
Kenya	KEN	*	*		**
Madagascar	MDG	*	*		**
Mali	MLI	*	*		**
Mauritania	MRT	*		*	**
Tanzania	TZA	*	*		**
Uganda	UGA	*	*		**
Zimbabwe	ZWE		*	*	**

Note: Countries scoring high growth rates and high production level in 2 or 3 commodity categories
(Author's computation based on IMPACT simulation results)

This analysis provides some guidance to regional and international organizations seeking to efficiently allocate their efforts to boost total SSA's supply of the key livestock commodities. The analysis can also help policy makers from individual countries to compare their country's performance vis-à-vis their peer countries.

National livestock development is largely driven by the overall performance of the respective national economy. The boom of the resource-intensive economies of SSA has shaped much of the economic performance of the region since the year 2000, driving up per-capita incomes and demand for multiple goods and services. The high-income elasticity of livestock-based goods has increased demand for livestock beyond the effect of rapid population growth. It should be noted that this demand increase has generally led to only modest increases of per-capita consumption of these goods (see Table 2).

The volatility of export revenues from oil and diverse minerals as well as the limited diversification of exports from many SSA countries make these market signals highly inconsistent, in addition to many other climatic and socio-economic factors that impact livestock prices at producer level. Given this volatility and the short-term low supply elasticity, particularly of ruminant animal production, many countries have relied on imports to service this growing demand. By comparison, model outputs show that the monogastric meat sector has generally higher growth rates of production, reflecting a higher elasticity of supply of short-cycle species such as poultry and pigs. The growth of Africa's per-capita incomes during the years 2000 to 2015 led to a growth in demand for animal-source foods beyond what the domestic production could supply. This is reflected by the fact that in 2015/17, all Sub-Saharan regions were net importers in US dollar in terms of meats, milk and feeds, except for Southern Africa in the case of beef and Western Africa in the case of feeds (Tables 6, 7 and 8). The IMPACT model simulations reported here predict that this will continue to be the case until 2030.

There is very limited comparative research on real prices of livestock products at producer or consumer level to help better understand the drivers of the evolution of actual consumption levels of these commodities. This difficulty is further compounded by the importance of informal markets for these commodities in most of SSA. Given the above considerations, it has proven difficult to associate

“success stories in livestock development” at the national level with specific policies to explain sector performance. Livestock development is driven by the medium-term economic performance of the national economy, political stability and conducive natural resource endowment.

In the next chapter, a range of specific technical and institutional/policy innovations that have the potential to significantly shift the development of the livestock sector in SSA are analyzed.

4 Innovation in the Sub-Saharan African Livestock Sector

4.1 The conceptual model

The study uses the conceptual framework of the induced innovation model in agriculture (Hayami and Ruttan, 1970) to understand the drivers of change and innovation. It also assesses institutions as major determinants of adoption and scalability of innovations. Country case studies for Ethiopia, Kenya and Mali commissioned by the Forum for Agriculture Research in Africa (FARA) and ZEF for the PARI livestock cluster project provide specific experiences. The institutions involved were IER (Kergna and Niallibouly, 2020), International Livestock Research Institute (ILRI) (Tegegne and Legese, 2019) and KALRO (Mose et al., 2020).

Major drivers of change influencing the SSA livestock sector development include: population growth; expansion of crop production; urbanization; the supermarket revolution and changing consumption patterns; growing awareness among consumers of food safety issues; opportunities provided by digitalization and de-intermediation; the expansion of international trade in livestock products; animal feed; cereals; and the decreasing cost of small-scale mechanization. These shifts lead to changes in relative prices of production factors, thereby creating opportunities for innovation.

There is a vast range of livestock innovations being developed in SSA. This study focusses on a selection of innovations that have moved beyond the research phase. They mostly address land-based ruminant production, a mainstay of rural livelihoods in SSA. Other innovations focus on making use of different resources and markets while creating employment for rural poor with limited access to land. Intensive beekeeping is such a case. Other enterprises with similar profiles (not covered by this study) include sericulture, backyard poultry or aquaculture. This study classifies innovations into more technical ones closely linked to feed, animal health and genetic improvement and more institutional and policy ones. Table 17 at the end of this chapter provides an overview of the innovations described in detail in the following sections.

4.2 Technical innovations

4.2.1 Improved *Brachiaria* forages

The innovation:

Brachiaria is an African genus comprising about 100 species. Extensive germplasm collection in Africa followed by strategic research on the agronomy, forage quality and animal production, genetics, cytogenetics, plant breeding, and biotic and abiotic stress adaptation over the past two decades in Latin America resulted in the selection of vigorous and productive *Brachiaria* grasses, as well as the development of four commercial hybrids (Mulato, Mulato II, Caymán and Cobra) through breeding. *Brachiaria* grasses have become the most widespread and economically important forage grasses in tropical America, and their adoption is increasing in East Africa and South East Asia. An estimated 90 million hectares are planted with *Brachiaria* in Brazil only. *Brachiaria* grasses stand out for their ability to be productive and persistent under low soil fertility conditions, with some genotypes showing contrasting and/or intermediate behavior in terms of their water use (i.e., ‘water saving’ or ‘water-spending’ behavior for their targeting to either long or intermittent drought periods respectively). In terms of climate change mitigation, *Brachiaria* grasses have a higher nutritional quality than many other commonly fed grasses and thus reduce the GHG emission intensity from enteric fermentation. In addition, they show a phenomenon termed ‘Biological Nitrification Inhibition’ (BNI) which refers to a mechanism by which roots—in particular those of *B. humidicola*—naturally inhibit the conversion

of nitrogen (N) in the soil from a stable form to forms subject to leaching loss (NO₃⁻) or to the production of N₂O, a potent greenhouse gas. This in turn has a direct environmental and economic effect (less N loss). Furthermore, *Brachiaria* grasses have the potential to increase carbon in soils (up to 6 tons/ha/year) due to their large root systems, chemical characteristics of its roots (high C/N ratio, lignin and polyphenols), and root turnover (one third of total root system might be renewed annually). Green house and field experiments have also indicated that soil physical attributes are greatly affected under *Brachiaria* (i.e. increase of aggregate size and water infiltration).” (Elbehri et al., 2017, p.44)

The *Brachiaria* innovation described above reflects the results achieved through long-term research in South America. Several *Brachiaria* cultivars were reintroduced to Africa and show promise as an alternative to Napier grass and as cut-and-carry forage for dairy farms (Maass et al., 2015; Pizarro et al., 2013). *Brachiaria* cultivars tend to outperform Napier grass in particularly drier environments and on acid soils.

Main drivers for adoption: The growing demand for dairy products and higher quality ruminant meat by expanding middle classes, particularly in urban areas of SSA, drives the search for better year-round feeding systems. Cultivated forages thereby become more competitive than alternative uses of arable land. By performing well in hotter environments and on acid soils, these forage plants expand the area where intensive animal production is feasible.

Status of the process: Widely grown Napier grass (*Pennisetum purpureum*) has developed disease issues. On the other hand, several *Brachiaria* species, cultivars and hybrids have been tested on station and on farm. They have shown particular promise on acid soils and during dry seasons, thereby expanding the range of environments where dairy production is feasible beyond those suitable for Napier grass growth. *Brachiaria* has also performed well as an alternative to Napier grass in push-pull settings, where it is used as a biological trap for maize stemborers.

Three *Brachiaria* types are commercially available in Kenya. All seeds are imported and undergo registration processes in several countries of the region (An Notenbaert, personal communication).

Adoption and impact studies: It is estimated from the seed volumes traded that several thousand hectares of *Brachiaria* grasses have been established on farms across Eastern Africa. On-farm trials have confirmed the acceptability of these materials (Mutimura et al., 2012; Maass et al., 2015). An ex-ante impact study conducted by González et al. (2016) documents significant potential producer and consumer benefits that could be achieved by investing in the diffusion of this innovation.

Potential for scaling up: The massive adoption of *Brachiaria* cultivars and apomictic hybrids in Latin America, the amount of research conducted in that part of the world and on-farm trials in Eastern Africa support the hypothesis of a “quick win” under African conditions. The ex-ante impact study estimated that significant areas of Eastern Africa would benefit from the adoption of the *Brachiaria* technology. Access to seed of improved cultivars is still a constraint, though smallholders are reported to be multiplying the material through vegetative propagation.

Lessons learned: Re-introducing improved forage plants at their locations of origin is associated with potential risks of pests and diseases. Some problems have been observed and will require further research in SSA. *Brachiaria* seed production and distribution are a significant constraint to be addressed.

4.2.2 *Improved fodder conservation*

The innovation: A bundle of innovations related to mechanical and chemical processing of crop residues and the production, transport and trading of hay allow a more efficient allocation of feed to animals, thereby increasing productivity, reducing seasonal variations and reducing GHG emission intensity per unit of output. Examples of the wide range of feed innovations are: grass hay production, baling of rice and wheat straw, chopping and urea treatment of straw, development of marketing

platforms for fodder and of small-scale mechanization for these services. This section builds largely on the Kenyan and Ethiopian case studies on livestock innovations (Mose et al., 2020; Tegegne and Legese, 2019).

Main drivers for adoption: The growing human population as well as economic development are leading to scarcity of grazing land, particularly in higher potential areas, causing an expansion of livestock production into areas with greater seasonal drought. This effect is compounded by the general increase in weather variability and the growing demand for milk and ruminant meat, particularly in urban areas. These drivers are creating increased demand for a year-round supply of higher-quality feed.

Status of the process: Crop residues are traditionally fed to livestock. Innovations consist of treatments involving labor and inputs to improve the quality and storability of feeds. Hay is being produced in Kenya's highlands, mainly by larger commercial farms. Additional, more recent innovations enable their wider adoption, particularly by smallholders. The growing availability of mechanization for crops, the development of small-scale agricultural machines, the organization of producers to create a market (e.g. for hay in Kenya), the breeding of crop varieties with more dual-purpose food-and-feed traits (e.g. stay-green gene in maize), the use of cell-phone technology to share information, and so on, all contribute to the gradual diffusion of improved feeding technologies.

Adoption and impact studies: Anecdotal evidence of initial adoption is available but no formal impact studies have been found.

Potential for scaling up: Access to small-scale mechanical equipment at competitive prices and with appropriate financing schemes as well as a regular supply of spare parts and services are gradually enabling smallholders and the landless rural poor to participate in this expanding market. The viability of individual technologies depends on the location-specific micro-economics of intensifying feed production and is frequently linked to a specific crop or specific agro-ecological conditions. The overarching trend of growing consumer demand for animal products and increasing pressure on land resources creates a vast opportunity for expanding use of feed intensification innovations and the products and services associated with it.

Lessons learned: Many feed innovations have been made available and are used by larger-scale commercial farms. The critical factor in implementation is ensuring smallholder access to formal markets and enabling them to take part in the growing urban market for animal-source products. The availability of low-cost small-scale mechanical equipment is important in enabling smaller operators to provide services. The development of the private sector (small and large) plays a critical role in allowing the feed value chain to expand (Technoserve, 2016).

4.2.3 Artificial insemination combined with estrus synchronization

The innovation: Artificial Insemination (AI) is a well-known technology used broadly to rapidly change the genetic make-up of livestock populations in response to changing production and market conditions. Combining AI with estrus synchronization in African smallholder settings reduces the cost of providing the service by bundling the demand within a community within a few points in time.

Main drivers for adoption: Classical artificial insemination has faced difficulties in its adoption in African smallholder systems beyond peri-urban dairy systems or government-funded schemes. In settings with poor road and communications infrastructure combined with a relatively low density of potential animals for insemination, the traditional model of providing AI services becomes expensive and inefficient. AI inseminators frequently arrive late to perform the insemination. Repeat inseminations further increase the cost per effective pregnancy achieved. These issues are described in detail for the Mali case by Kergna and Niallibouly (2020).

African livestock keepers face a conundrum when they seek to intensify animal production. On the one hand, local breeds are well adapted to harsh environments but of low productivity. On the other

hand, temperate breeds have been selected for high productivity but are not well adapted to tropical environments. Livestock keepers have sought to combine these breeds through indiscriminate crossbreeding their local animals mainly with European breeds but also with Indian and Brazilian tropical breeds. Due to a lack of pedigree recording, strong genotype-by-environment interactions as well as the difficulty in maintaining a stable proportion of indigenous to introduced breeds, genetic selection and breeding under African smallholder conditions have not been very effective. Developments in genomics, rapid expansion of cellular communications, experiences in community-based breeding programs now create conditions for more effective genetic improvement (see Marshall et al., 2019). Such developments have the potential to significantly increase the demand for artificial insemination in SSA.

Status of the process: Veterinary products to synchronize estrus in cattle were developed for seasonal dairy production systems with the aim of synchronizing time of calving within a dairy herd to better align the feed requirements of the dairy herd with the seasonality of growth of forages. They have also enabled dairy farmers in New Zealand to close the milking operation for some time each year for vacations.

In Ethiopia, researchers identified the opportunity to use this product to synchronize cows and heifers at the local community level. This would enable the inseminator to treat a large number of animals in one go and these animals would be inseminated at the optimal timing to increase the conception rate. Several studies were undertaken in Ethiopia to test the feasibility of the approach (Gizaw et al., 2016). The main finding was that results were highly dependent on the know-how of the inseminators. The use of the technique with sheep is also being explored (Gizaw and Tegegne, 2018).

Adoption and impact studies: At present, several regions of Ethiopia are testing the feasibility of using this method at scale. At this stage, no formal adoption or ex-post impact studies are available.

Potential for scaling up: This technology implies the use of additional inputs to synchronize the estrus. It is attractive for remote areas, where conventional AI services are not efficient. Changing breeds to higher producing ones needs to be associated with higher intensity of management, access to appropriate animal genetics and particularly feeding in order to achieve greater animal performance.

Lessons learned: To function effectively, animals to be synchronized and inseminated need to be in adequate physical condition, so that frequently, only a share of the potential animals in a community can be inseminated at any one point in time. This approach requires collective action to assemble a reasonable number of animals to be inseminated in order to make it economical. The staff performing the AI need to be skilled and familiar with the issues associated with estrus synchronization. The treatment of pregnant animals can cause abortions. Early experience suggests that capacity building plays a critical role in making this innovation successful at field level (Tegegne et al., 2013). A specific niche for the technology seems to be as part of programs which aim to rapidly build up the dairy herd as a possible alternative to large-scale importation of dairy cattle.

4.2.4 Intensive Beekeeping

The innovation: Traditionally, wild bee colonies are periodically “hunted”, and honeycombs harvested. In some regions, traditional log hives are placed in trees, colonized by bees and periodically harvested. The main innovation is the intensification of production, generally by using modern hives, which enables the beekeeper to manage the colonies and harvest honey more efficiently. Ethiopia is a particularly interesting case because of the large number of wild and traditional hives, the high potential for the production of honey and beeswax and the multiple efforts over the last four decades to introduce modern beekeeping as an income source. In 2017, Ethiopia was SSA’s third largest exporter of honey and its largest exporter of beeswax (FAOSTAT, 2020).

Main drivers for adoption: Beekeeping is recognized as an opportunity for income generation for youth and women that is not dependent on land ownership. Demand for high-quality honey is high in domestic and international markets. Limited use of pesticides in most African farming systems enables

the production of honey and wax without pesticide residues. Furthermore, the activity can be successfully developed in environments that are marginal for annual crop production. Honey and beeswax attain relatively high prices per kg, which makes them worth being transported over long distances. Both products are imperishable. Investments to start beekeeping are low and spread out over time. Most inputs can be produced locally, which creates additional jobs and livelihoods in the value chain.

Status of the process: Multiple development agencies and civil society organizations have supported the Ethiopian government in its efforts to develop the apicultural sector in recent years. The aim has been to develop the Ethiopian value chain from the provision of inputs all the way to the promoting of honey and beeswax exports. The SNV-ASPIRE and the ATA-EAAP projects were particularly active in this field (SNV, 2019; ATA, 2018).

The issue of capacity building for beekeepers has emerged as a central challenge given the massive scale and diversity of the conditions in which an estimated 1.5 million beekeepers operate nationwide. Most of them are largely used to handling traditional hives; intensive “modern” beekeeping implies a major change for them. This requires a massive capacity-building effort. The project ASPIRE organized capacity building by using existing beekeepers trained as lead beekeepers to share their knowledge with follower beekeepers. They reached 31,376 beekeepers (21% female) and 33,290 copy beekeepers (20% female) over five years (SNV Netherlands, n.d.). YESH’s (Young Entrepreneurs in Silk and Honey) strategy was to target unemployed youths and women who indicated interest in beekeeping with the help of the extension service. The project recruited 6,447 youth by the end of the third year who established 573 group enterprises. Twenty percent of the enterprises and 30% of the youth eventually dropped out due to lack of viability of the enterprises (YESH, 2019).

Lessons learned in implementing the YESH project include: providing increased flexibility in composition of starter kits; more flexibility in the way youth groups operate; encouraging local honey market development; and involving experienced local beekeepers in the training of youth. These lessons are being taken into account in the implementation of the scaled-up project MOYESH (More Young Entrepreneurs in Silk and Honey). The project aims to reach 100,000 youth through sericulture and beekeeping development (Ayalew, 2020, personal communication).

The macro-economic environment has not been conducive to the expansion of honey exports in recent years. The prevailing exchange rate and high cost structure of bulking up honey from large numbers of small producers and the costs of complying with international quality standards make exporting difficult. The domestic market, with lower quality standards and shorter distribution chains to consumers, has proven more attractive than the export market. Honey exporters are facing challenges in developing the value chain and establishing stable relationships with beekeepers and their grouping for such exports. The rapid growth of the Ethiopian economy in recent years has furthermore increased the domestic demand for honey.

Adoption and impact studies: Adoption of modern beehives is very limited in Ethiopia. According to the Central Statistical Agency of Ethiopia, in 2017/18, the country had about 6.5 million managed beehives, out of which only 127,000 were modern hives with movable frames (Tegegne and Legese, 2019).

Studies most related to adoption are reports of the two recently completed projects ASPIRE, managed by SNV and funded by the Netherlands Embassy in Ethiopia, and YESH, which was implemented by the International Centre of Insect Physiology and Ecology (ICIPE) and funded by the Mastercard Foundation. Both projects faced a number of challenges related to the capacity building approach, the incentives and the broader development of the apicultural value chain.

Potential for scaling up: The potential in Ethiopia is based on the combination of favorable agro-ecological conditions for beekeeping and the large share of unemployed rural youth (Tegegne and Legese, 2019). The key issues involved are the institutional arrangements required to provide training to these youth, the provision of credit and the inputs needed, the organization of beekeepers in

sharing harvesting infrastructure and the development of value chains for diverse markets. These aspects will require well-coordinated interplay between the government, private sector, NGOs and farmer organizations.

Lessons learned: The emphasis of most apiculture development projects in Ethiopia and elsewhere in the developing world has been on the transition from traditional beehives to modern beehives. Empirical evidence shows that intensive beekeeping is very knowledge intensive. Capacity-building is critical to realize the benefits of beekeeping with movable frame hives. This is particularly challenging with aggressive African bees. Exporting honey requires complying with high-quality standards (lack of pesticide residues, correct humidity, etc.). Honey value chains for exporting are complex and require trust and the enforcement of stringent rules and regulations in order to be efficient and internationally competitive. These institutional developments take time to develop. Domestic markets are easier to access, particularly in the earlier stages of developing the apiculture sector.

In summary, Ethiopia's vast bee-keeping potential can be expected to be realized gradually in line with the development of domestic prices for honey, the development of the knowledge base for appropriate beekeeping under Ethiopian conditions and the diffusion of such knowledge. Beekeeping will probably remain a side-line for many farmers while, over time, a small proportion of them as well as interested youth and women will engage more deeply in this knowledge-intensive business. The large amount of experimentation that took place in Ethiopia during the last decade on developing honey value chains, organizing training and knowledge transfer to large numbers of aspiring beekeepers, developing schemes for youth employment and financing beekeeping operations is a valuable resource for future investments seeking to develop the apiculture sector in Ethiopia and more generally in SSA.

4.3 Policy/institutional innovations

4.3.1 *Livestock master plans*

The innovation: Groups of stakeholders, including governments, the private sector, research and development organizations and civil society, jointly develop a vision for livestock development in their country and establish a five-year plan for key sub-sectors using a toolkit called LSIPT (Livestock Sector Investment and Policy Toolkit). This toolkit (Alary et al., 2014) was developed under the umbrella of ALIVE (African Partnership for Livestock Development) by the World Bank and the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD) with inputs from FAO and ILRI. It is comprised of several modules and links farm-level models to economy-wide models of the livestock sector.

Main drivers for adoption: Development interventions in the livestock sector have been hampered by the lack of consistent data on the stocks and performance of the multiple livestock systems found in any given SSA country. Furthermore, interventions have frequently been very narrow, such as artificial insemination schemes, vaccination campaigns and establishment of abattoirs, and have failed to deliver expected benefits due to the lack of consideration of trade-offs and co-benefits both within the livestock sector and beyond (e.g. food security, climate change, social development, human health and nutrition, etc.). Livestock master plans attempt to comprehensively improve human well-being through a livestock development lens.

Status of the process: Livestock Master Plans have been developed in Ethiopia (Shapiro et al., 2015), Tanzania (Michael et al., 2018), Rwanda (Shapiro et al., 2017) and the State of Bihar, India (Shapiro et al., 2018) using the LSIPT toolkit framework. The modeling components of the toolkit are being further refined (Karl Rich, personal communication). Present versions put a heavy emphasis on key value chains, further explicit consideration of interactions in different markets between subsectors (e.g. competition for feed), as well as impacts in terms of GHG emissions, human nutrition and health, and

gender, which would enable more robust assessment of interventions in terms of their overall contribution to human development.

Adoption and impact studies: There is some evidence of the use of these masterplans by governments and international financial institutions when establishing national development plans and designing new loan programs. Formal assessments on their impact are not available.

Potential for scaling up: The concept of masterplans and the LSIPT models are clearly scalable, though the very nature of the complexity of each country's situation requires case-specific data collection, local expert input and a political buy-in to enable masterplan findings to lead to concrete policy changes.

Lessons learned: There is a need to develop more comprehensive models that better capture the interdependencies of diverse aspects. In many countries, institutional challenges exist in getting engagement from sectors beyond livestock (finance, nutrition, environment, health, economic development, gender) and developing consensus for action. This is particularly critical for livestock development-related issues given their very wide systemic ramifications.

4.3.2 Livestock asset transfer programs

The innovation: Livestock ownership provides poor people, particularly landless ones, with opportunities for using their labor as entrepreneurs, frequently with a higher labor productivity, than as wage earners in their region. In contrast to land ownership, women are frequently allowed to own livestock, particularly small livestock and to control the income derived from it. Livestock ownership enables poor people to use open-access resources such as communal rangelands to produce highly valued goods like meat and milk, animal traction, and so on. Livestock provide emergency liquidity and frequently regular income (e.g. from milk). In many contexts where formal financial instruments cannot be accessed by the rural poor, livestock is one of the few ways to accumulate assets, particularly when inflation is high.

Livestock asset-transfer programs build on these unique features of livestock by giving the poor culturally and technically appropriate livestock, such as a dairy heifer, piglets, small ruminants or chicken. To qualify, recipients are generally required to participate in certain capacity-building activities. In some cases, additional cash is provided to enable the recipient to purchase inputs required to sustain production until revenue from farm-activities starts to come in. Many programs have a feature of "passing on the gift," where beneficiaries commit to handing over the first female offspring to another recipient to expand the benefits.

Main drivers for adoption: The unique features of livestock have made it an asset of choice in many asset-transfer programs. The size and elasticity of the markets for meat and milk make it feasible to provide a significant number of poor people with this asset. Basic know-how on livestock keeping is available among the rural poor. Besides small amounts of relatively regular income, livestock asset-transfer programs have been shown to significantly improve diet diversity, gender empowerment, and general sense of well-being (Staal et al., 2019).

Status of the process: Livestock asset transfers have a long tradition as marriage dowries in many societies and as a pro-poor development intervention. NGOs such as Heifer International and Send a Cow have over many years implemented livestock asset-transfer programs worldwide. They have, however, generally had a limited scale, been linked with capacity building and considered relatively expensive to implement. Nonetheless, the Rwanda experience of transferring over 120,000 cows has shown that operating livestock transfer programs at scale is possible.

Adoption and impact studies: Rigorous impact studies including large random control trials have, in recent years, documented the multi-dimensional impact of such interventions in SSA and Asia (Banerjee et al., 2015).

An impact study on Rwanda's Girinka program documented the importance of capacity-building in addition to the provision of a cow (Argent, 2014). An impact study on the Heifer International asset-transfer program in rural Zambia documented small daily expenditure increments. These led to significant improvements in household nutrition and self-assessed general well-being. In this case, beneficiaries were able to choose the asset they received: dairy cattle, goats for meat or draft cattle. The choice of asset had an impact on the nature of benefits. Benefits began after six months and were ongoing after 18 months (Kafle et al., 2016).

The Pigs for Peace (PFP) program in the Democratic Republic of Congo provided mostly women with one female piglet, access to capacity-building and cash. The aim of this trial was to evaluate the effectiveness of a hybrid microcredit/livestock asset-transfer program on economic, health and intimate partner violence outcomes using a randomized community trial. The results confirmed economic and nutrition benefits and showed positive psycho-social effects (Glass et al., 2014).

Potential for scaling up: These programs tend to be labor-intensive and have relatively high cost per beneficiary, which limits their large-scale implementation. They are sometimes compared to unconditional cash-transfer programs, which are simpler to scale up. When the rural poor have been given cash transfers, livestock are frequently the purchased asset of choice. Impact studies have documented the importance of combining asset transfers with capacity-building measures and some money (Argent et al., 2014). The important role of livestock assets as a pathway out of poverty was also documented for Western Kenya (Kristjanson et al., 2004).

The solid evidence of the impact of livestock asset-transfer programs, including randomized control trials, unearthed in recent years supports further scaling up. Detailed analyses of the specific situations of each target group would be required to ensure that other constraints, such as access to feed resources, markets or critical inputs, do not unduly impair the productivity of the livestock given. The key to broader scaling up of this approach is to find ways to deliver this intervention as a private-sector initiative or as a private-public partnership.

Lessons learned: It is critical to link livestock asset transfers with related capacity-building. Recipients should be allowed to choose the livestock species they will receive. The cultural and technical fit of the proposed livestock species to the recipient's context is critical for success.

4.3.3 Index-based livestock insurance (IBLI)

The innovation: "Index-based" insurance schemes reduce the impacts of livestock losses due to severe dry spells by compensating livestock keepers when the forage in an area becomes depleted by drought. This helps herders who take out insurance to recover from drought. Pay-outs are pegged to measurements of forage conditions on vegetation cover made via satellite data to derive an index of seasonal forage availability and scarcity. Payouts to insured herders are made not when they lose their animals, but rather when the forage in their area is shown to fall below a certain productive threshold (ibli.ilri.org website, consulted 31.3.2020).

Main drivers for adoption: In development economics, the ability of insurance to address poverty and specifically poverty traps is widely recognized. Insurance enables asset protection and consumption smoothing during shocks. Pastoralists in the African drylands are generally poor and are periodically affected by severe droughts, the most serious risk they face. Drought is a co-variate risk that affects most livestock keepers within a region, making community-based systems of sharing risk not effective. Administration costs and moral hazards have limited the feasibility of conventional insurance approaches based on indemnifying individual cases of losses. Index-based insurance overcomes these issues.

Status of the process: In line with broader interest in index insurance in agriculture in the early 2000's, a group of researchers from Cornell University, UC Davis and ILRI conceptualized the idea of an index-based drought insurance for pastoralists in Kenya. Over time, a vast array of studies was conducted, with multiple development partners including insurance and reinsurance companies and the Kenyan

government joining the effort and gradually tackling a range of practical issues associated with delivering this product to the drylands of northern Kenya. IBLI is probably one of the best-studied institutional innovations related to the livestock sector published in prestigious journals.³

The Kenyan government established the Kenya Livestock Insurance Program and implemented IBLI in a growing number of counties in the Northern drylands. Implementation was done through a private-sector insurance company and technical backstopping was provided by ILRI and its research partners. In 2018, WFP and partners started testing a component of index-based livestock insurance with 5,000 participants within the SIPE (Satellite Index-Insurance for Pastoralists in Ethiopia) project in the Somali region of Ethiopia (Matsuda et al., 2019; Fava, Jensen and Banerjee, 2020).

Adoption and impact studies: It is estimated that at the time of writing (March 2020), approximately 18,000 pastoralist households or 80,000 beneficiaries were covered by livestock index insurance. The Kenya Livestock Insurance Program provides subsidized insurance to targeted beneficiaries in eight counties in northern Kenya (Fava, Jensen and Banerjee, 2020).

Risk is considered a major poverty trap. Insurance avoids asset depletion and allows consumption smoothing. Recent studies have documented additional benefits of risk reduction driven by factor deepening even in years without shocks. Emerick et al. (2016) showed that new rice varieties tolerating flooding produced higher yields in years without flooding by allowing farmers to use more inputs. Similarly, Jensen, Barrett and Mude (2017) showed that IBLI led pastoralists to reduce precautionary savings, reduce herd sizes, crowd in inputs and thereby intensify livestock production, leading to an equivalent increase in income per adult. They showed that IBLI was more cost effective as a social protection approach than cash transfers in the Kenya case.

Potential for scaling up: Besides Kenya and Ethiopia, feasibility studies have been conducted with development partners for Niger and Somalia. Another study has also been commissioned for Senegal, Mali, Burkina Faso and Niger. WB, AfDB, African Risk Capacity, IGAD and their partners are planning a drought risk financing initiative for the Horn of Africa that will include livestock index insurance (Fava, Jensen and Banerjee, 2020).

Private sector insurance and re-insurance companies have been involved in the Kenyan and Ethiopian cases. IBLI is seen as an effective social policy instrument in settings where drought is a major risk for the livelihoods of poor livestock keepers. The Sahel region clearly qualifies as a potential setting for this innovation. At present, the main constraint is the high cost of distribution, which implies a need for government or donor support.

Lessons learned: While index insurance is very attractive as a concept, experience has shown that its adoption by the rural poor has generally been below expectations. In the Kenyan case, about one-third of potential clients bought the insurance, frequently insuring only part of their herd. The concept of insurance has sometimes been difficult to convey to pastoralists and the basis risk related to the index has deterred clients. The cost of delivering the service through present distribution channels remains relatively high given the vast regions where pastoralists operate, the effort needed to explain the concept and the small amounts each client tends to insure. With current technology, livestock index insurance is an effective social policy intervention in addressing poverty among pastoralists subject to high periodic drought risk, as long as premiums are subsidized at least in part. Delivery can be handled by the private sector. Highly volatile public expenditures for relief can thereby be turned into the predictable cost of providing a regular subsidy for insurance premiums.

4.3.4 *Livestock market information systems*

The innovation: Market information systems (MIS) have been considered a key intervention in improving market transparency and efficiency, informing agriculture and food policy, and improving

³ See <https://www.drylandinnovations.com/journal-articles> and <https://www.drylandinnovations.com/briefs-case-studies-summaries>

equity. But the sustainability and relevance of such services has been generally poor (Galtier et al., 2014). The digital revolution has, in recent years, brought forward technologies and related business innovations (e.g. the concept of platforms and network effects, combining the delivery of free and paid services) that promise to change the economics of providing and using such market information.

Main drivers for adoption: Poor livestock keepers are the main suppliers of animals in most developing-country livestock markets. These markets are generally considered to be inefficient given the asymmetry of information, the difficulties in grading animals and the poor physical infrastructure for the livestock trade. Providing smallholder livestock keepers with market information is expected to lead to higher producer prices, increased incomes and reduced poverty as long as other constraints, notably poor physical infrastructure, are addressed in parallel. Given the nature of livestock as a commodity (relatively high value per unit, live animals are not very perishable, time of sale can be managed), livestock markets tend to be seen as more efficient than those of perishable commodities, such as most fruit and vegetables or raw milk.

Difficulties in running conventional livestock MIS and making their benefits visible have generally led to underfunding by governments, forcing them to rely on short-term donor funding. Most schemes have therefore not been sustainable. The massive adoption of cell phones and smartphones in Africa and rapidly improving network coverage in rural areas are now enabling innovative, low-cost and scalable approaches to collect, curate and distribute livestock market data more feasible (Banerjee, 2019).

Status of the process: USAID has been a long-term supporter of the development of agricultural MIS in SSA. Projects in Mali, Kenya and Ethiopia have been established over the last decade with government agencies and technical back-up from American universities. The Feed the Future Mali Livestock Technology Scaling Program supported the development of a web-based livestock market information system developed by Texas A and M University, the Observatoire du Marché Agricole (OMA) and the Direction Nationale des Productions et des Industries Animales (DNPIA). It relies on trained staff reporting information from diverse livestock markets following established protocols via short messaging service (SMS). The data are centrally analyzed, and market reports are distributed in written form via SMS and posted on the website⁴. The challenges this system is facing are related to the quality of the data reported, its limited use by pastoralists, who are frequently illiterate, and the dependency on donor funding (Kergna and Niallibouly, 2020; Wane et al., 2016).

Similarly, the Ethiopian livestock MIS operates on the basis of SMS reports from trained staff based at the major markets. The system has been recently re-launched.⁵

Kenya has undertaken multiple efforts to develop a livestock market information service. The present national system NLMIS⁶ operates similarly to the Ethiopian and Malian systems. Efforts are underway to coordinate multiple ongoing initiatives in recording livestock market information in Kenya. The aim is to establish a regional livestock market information system under IGAD.

Adoption and impact studies: Impact studies on MIS are particularly challenging methodologically, given the nature of benefits ranging from public goods such as improved policy design and increased equity among market participants to private benefits of reduced transaction costs for information users (Staatz et al., 2011). Quantitative information on the use of the described systems and the value seen in them by market actors could not be found. Research on MIS for crops has shown that impacts are often limited because other factors such as established business relationships, dependence on

⁴ See www.malibetail.net.

⁵ See <http://www.lmiset.gov.et/lmis/home.htm?action=getData> and <https://blog.ciat.cgiar.org/strengthening-institutional-and-human-capacity-on-national-livestock-market-information-system-in-ethiopia> for further details.

⁶ See <http://www.lmiske.go.ke/lmis/home.htm?action=getData>.

buyers for credit, limited storage facilities or trust are more influential in shaping marketing decisions than price information (Baumüller, 2018).

Potential for scaling up: Technologies such as crowd sourcing, allocation of observational tasks to interested actors, digital payment for such services and other platform-based business model elements have chiefly been deployed successfully in other sectors and contexts. They could markedly change the cost, speed, and quality of the information gathered. The project KAZNET has been piloting such solutions in Kenya (Banerjee, 2019). Results to-date seem promising and should be quite widely scalable. Applying the overall platform-based business model to sustainability is still challenging and will have to be addressed case by case.

Lessons learned: Conventional livestock MIS in SSA have been challenging to establish and operate sustainably beyond the donor-funded start-up phase. Grading of animals transacted has been problematic but is essential in order to have comparable prices. Additionally, most animals are transacted per head and not per kg of weight.

Benefits to poor livestock keepers may not be realized because of other factors limiting their capacity to make use of market information. Examples of such limitations include the small number of animals sold, making transportation to distant markets uneconomical, and lack of knowledge or trust in unknown traders. Furthermore, many systems distribute information in writing, even though livestock keepers are frequently illiterate. Widely used cell phone technology enables livestock keepers to directly tap into information, such as prices in different markets in real time, from trusted sources. Information systems need to provide a significant value added beyond these informal but trust-based information sources.

Platform-based business models frequently achieve financial sustainability by giving away certain services while selling other goods and services. Up until now, there have been few concrete cases of services or goods combined with market information where pastoralists have shown willingness to pay. Other actors (e.g. livestock traders, input suppliers, government) may be more willing to pay for such market information.

Tab 17: A Selection of Scalable Innovations for the Livestock Sector of SSA

Innovation	Issue addressed	How it works	Main driver	Maturity	Current constraints	Main adopting sub-region/country in SSA	Experience outside SSA
Improved Brachiaria forages	increasing feed scarcity	improved cultivar adapted to acid soils and dry conditions; plant suitable for cut-and-carry systems	private/public/NGOs	several thousand farmers testing innovation in Eastern Africa	seed production; reintroduction to Africa with potential pest and disease risk	Eastern Africa	ample adoption in LAC
Improved fodder conservation	increasing feed scarcity; seasonality of supply	processing increases quality and marketability of forages and crop residues	private sector; farmers; NGOs; regional or local level	well developed	capacity building of farmers; value chain development; small-scale mechanization	Kenya	ample, particularly in Asia
AI with estrus synchronization	low productivity of indigenous breeds	allows rapid deployment of improved breeds	regional governments	intermediate	limited availability of trained inseminators; sub-optimal conditions of animals to be inseminated	Ethiopia	used commercially in New Zealand
Intensive beekeeping	lack of employment for rural youth without access to land	small investments combined with knowledge transfer enable income generation, particularly in marginal areas	NGOs, governments at regional level	intermediate	technical knowledge of tropical beekeeping; capacity building at scale	Ethiopia, Kenya, Tanzania	widespread, particularly in LAC

Innovation	Issue addressed	How it works	Main driver	Maturity	Current constraints	Main adopting sub-region/ country in SSA	Experience outside SSA
Livestock Master Plans	complexity of livestock systems limits effectiveness of individual policy interventions	models address synergies and trade-offs among policies simultaneously	government ministries	rolled out in several countries	complex interactions difficult to model, buy-in from multiple policymakers required	Eastern Africa	Bihar, India
Livestock asset transfer programs	lack of assets closely associated with poverty	(rural) poor receive livestock assets and capacity building	NGOs, development cooperation, some governments	well developed	financing and managing such programs are complex	across Africa	many, long term
Index-based livestock insurance	drought is a major poverty trap for pastoralists	weather index triggering payments reduces moral hazard and transaction costs	governments, NGOs, insurance companies	implementation ongoing in Kenya and Ethiopia	novelty of approach requires heavy marketing investment and subsidies	Kenya, Ethiopia; feasibility studies ongoing in West Africa	multiple for crops, Mongolia for livestock
Livestock Market Information Systems	asymmetry of access to market information puts poor livestock owners at a disadvantage	livestock market information gathered and distributed publicly	public market agencies	developed	sustainability of business model, cost and timeliness of data collection	Africa	globally

(Author's compilation)

5 Conclusions, Lessons and Policy Implications

5.1 The unique features of the SSA livestock sector

The SSA livestock sector contributes from 30 to 50% of the agricultural GDP of the region and provides livelihoods to an estimated 160 million poor livestock keepers. The sector will continue to be important to SSA's development for multiple reasons: high competitiveness given the factor endowment of vast parts of the continent, large numbers of livelihoods attached to the sector, many of them with few alternatives, and a growing demand for animal-based products.

SSA contains a highly heterogeneous mosaic of livestock production systems ranging from extensive pastoralist systems in the drylands to smallholder mixed crop-livestock-tree systems in the humid and sub-humid zones and smallholder dairy systems in the East African highlands, as well as from ubiquitous scavenging backyard poultry systems to large-scale commercial poultry production in coastal and metropolitan areas. Much of this production comes from smallholders and is transacted in informal markets, both domestically and across national borders. This explains the challenge of obtaining quantitative information on what is actually happening in the sector. This is also reflected in the difficulties the FAO faces in providing solid, internationally comparable data on this sector.

The SSA livestock sector has significant growth potential driven by the growth of both population and per-capita demand starting from low per-capita consumption levels. This also implies significant employment and livelihood opportunities if the policy environment is conducive. A major challenge in achieving this is the growing difficulty for smallholders to participate in formal, particularly urban markets due to their requirements of high volumes of safe animal products of a given quality (the supermarket revolution).

The livestock sector is characterized by its high systemic complexity. It has multiple co-benefits and trade-offs: animals serve as outputs as well as assets for wealth storage and further stock number expansion and its outputs are critical wage goods, which are highly valuable in enhancing diets at low levels of consumption, but contribute to non-communicable disease (NCD) prevalence at higher consumption levels. Livestock commodities are also produced mainly by the rural poor and consumed by wealthier urban middle classes. This complexity and the fact that livestock's contribution to GDP tends to be low in developing economies and gradually grows as incomes per capita rise has tended to lead to a benign neglect of the sector in terms of public attention and public investment.

5.2 The outlook for the SSA livestock sector

Outlooks for the SSA livestock sector (FAO, 2009; Herrero et al., 2014) coincide in their assessment that, given the relatively high population growth expected as well as GDP growth, demand and supply of animal-source foods will grow significantly in the region during the coming decade and beyond. This is also supported by the scenario analysis reported in chapter 3 of this report. This should lead to increased trade and increased domestic production, while the region as a whole would remain a net importer of animal protein. These conditions and the growing formalization of the trade in animal-source foods as well as the increasing food safety and quality standards demanded by urban consumers will create opportunities for private-sector investment along the various value chains.

Climate change is widely considered the overarching development issue for the coming decade. It is driving innovation and technical change for adaptation in SSA agriculture. Pastoralists are diversifying animal species (reducing cattle, increasing small ruminants and camels) in the Sahel and the Horn of Africa. Feed systems are changing in response to climate change and increased weather variability. No single innovation will solve the adaptation challenge by itself; a whole array of system- and location-specific interventions will have to be deployed.

This report was being finalized when the Coronavirus pandemic exploded worldwide. A UNU-WIDER study on poverty impacts of the pandemic concludes that significant increases in poverty, particularly in SSA, are to be expected (Sumner et al., 2020). Though still in the early days, some economic impacts of the pandemic on the results of this study can already be foreseen:

1. Demand growth is a key driver of livestock development. The scenario analysis done using the IMPACT model for 2030 is probably somewhat overestimating GDP growth for the coming years and consequently also demand and supply growth. The pandemic can be expected to reduce growth significantly over the next several years.
2. The increase in poverty will make livestock as a livelihood and an asset important for the rural poor, particularly those in the drylands who have very limited livelihood alternatives. Policies aiming to strengthen the social protection role of livestock for poor livestock keepers will contribute to address the increased challenge of achieving the SDGs after the pandemic.
3. The pandemic will probably increase global interest in combating zoonoses in developing countries. Wet markets, which are very important for the poor, are presently at the core of the debate on the origin of the Covid-19 virus. Bushmeat, an important source of animal protein in parts of SSA, is a known vector for zoonoses such as HIV-AIDS. The role of wet markets and the consumption and trade in bushmeat should get higher public health attention in the coming years.

5.3 Policy implications

The growing importance of the sector and associated challenges (zoonoses, climate change, rural poverty, rangeland management, etc.) require a more proactive engagement with the sector than has been usual in the past. This will demand commitment of human and financial resources to understand the issues and design and to implement smart policies in a complex context. For policymakers, it is essential to invest in the analytical capacity to understand the underlying functioning of livestock systems in order to identify interventions that are effective in each specific situation. Given the complexity of SSA livestock systems, this requires specialized expertise as well as national and international knowledge-sharing.

Among the macro-economic issues influencing SSA, livestock development is an issue of balance of payments, sources and uses of foreign trade. Economies reliant on agriculture as a source of international exchange see livestock exports as a pathway to economic growth, while other economies depending on non-agricultural commodity exports tend to rely on animal-source food imports to an important extent. Understanding the trade-offs involved and the long-term international competitiveness is critical when making investment decisions such as the development of disease-free zones, abattoirs for exports, and the like.

Reviewing the innovations featured in this report shows the critical importance of capacity-building and knowledge-sharing at an operational level among farmers, extensionists and input suppliers in enabling the effective adoption of many innovations. Digital technologies disrupting capacity-building and knowledge-sharing are making it more cost-effective and faster.

Innovations are frequently developed as projects run by development NGOs, but reaching scale generally requires government or private sector intervention. Ensuring a policy environment that fosters private-sector involvement is critical for the diffusion of many promising livestock innovations.

Many innovations do not go to scale. Linn (2019) analyzed conditions for scaling up interventions. He found that the complexity of interventions was frequently a problem. To increase their success rates, innovations have to be simplified (scaling by subtraction) and scaling up had to be considered from

the initial design phase. Given the inherent complexity of developing the SSA livestock sector, the need for simplicity is a major challenge for scaling up.

Moreover, multiple interdependencies within these farming systems frequently put a ceiling on the marginal productivity and therefore feasibility of adopting specific innovations such as artificial insemination and supplementation of feeds. On the other hand, some innovations that reduce risk (e.g. fodder conservation, livestock insurance) have been shown to encourage other intensification interventions, thereby increasing the impact of these interventions.

Given the magnitude of the expected demand growth, policy makers need to also address demand-side policies related to animal-based food. Consumer education in nutrition, NCDs and food safety needs to support appropriate levels of protein consumption by all parts of society.

5.4 Final remarks

Innovations building on the comparative advantages of the SSA's livestock sector and exploiting new technologies can significantly contribute to sustainable development and achieving the SDGs in the region. Livestock is considered very differently among developed economies and SSA. The global interconnectedness of issues (international markets, global movement of diseases, climate change, migration movements) nevertheless leads to a shared interest in innovations tackling major challenges. This common agenda includes issues such as mitigating and adapting to climate change, reducing the burden of antibiotic use, developing vaccines against major diseases (e.g. African swine fever), particularly zoonoses, exploring alternative sources of protein and dealing with NCDs. This shared need to address globally relevant livestock-related issues is a strong argument for worldwide cooperation and knowledge coproduction.

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Annex 1: Sub-Regional grouping of countries of Sub-Saharan Africa following FAOSTAT

Eastern Africa	Burundi (BDI), Comoros (COM), Djibouti (DJI), Eritrea (ERI), Ethiopia (ETH), Kenya (KEN), Madagascar (MDG), Malawi (MWI), Mauritius (MUS), Mozambique (MOZ), Reunion (REU), Rwanda (RWA), Seychelles (SYC), Somalia (SOM), South Sudan (SSD), Uganda (UGA), Tanzania (TZA), Zambia (ZMB), Zimbabwe (ZWE)
Middle Africa	Angola (AGO), Cameroon (CMR), Central African Republic (CAF), Chad (TCD), Congo (COG), Democratic Republic of Congo (COD), Equatorial Guinea (GNQ), Gabon (GAB), Sao Tome and Principe (STP)
Southern Africa	Botswana (BWA), Eswatini (SWZ), Lesotho (LSO), Namibia (NAM), South Africa (ZAF)
Western Africa	Benin (BEN), Burkina Faso (BFA), Cabo Verde (CPV), Cote d'Ivoire (CIV), Gambia (GMB), Ghana (GHA), Guinea (GIN), Guinea Bissau (GNB), Liberia (LBR), Mali (MLI), Mauritania (MRT), Niger (NER), Nigeria (NGA), Senegal (SEN), Sierra Leone (SLE), Togo (TGO)

Annex 2: IMPACT Model results

Production Estimates for Ruminant and Monogastric Meat, Milk, by Country, 2010-2030⁷

Country		Ruminant Meat		Monogastric Meat		Milk	
		2010	2030	2010	2030	2010	2030
1000 metric tons							
Angola	AGO	108	168	43	64	261	362
Benin	BEN	34	53	24	43	40	66
Botswana	BWA	48	78	7	13	122	192
Burkina Faso	BFA	186	340	96	211	250	431
Burundi	BDI	20	33	16	27	28	40
Cameroon	CMR	150	279	108	234	247	421
Central African Republic	CAF	101	149	25	48	77	132
Chad	TCD	139	227	7	13	284	430
Congo	COG	6	10	9	19	1	2
DRC	COD	41	105	45	117	7	15
Eritrea	ERI	36	58	2	4	125	160
Ethiopia	ETH	568	1086	56	115	1676	2975
Gabon	GAB	3	4	9	16	3	4
Gambia	GMB	6	11	2	4	10	17
Ghana	GHA	55	119	50	122	42	82
Guinea	GIN	65	151	9	28	118	278
Guinea-Bissau	GNB	8	13	16	30	22	35
Ivory Coast	CIV	49	105	37	92	34	67
Kenya	KEN	553	935	41	71	3619	5390
Lesotho	LSO	17	30	10	19	32	52
Liberia	LBR	3	6	16	39	1	2
Madagascar	MDG	162	281	123	219	561	762
Malawi	MWI	40	75	42	72	38	57
Mali	MLI	220	400	46	84	711	1050
Mauritania	MRT	79	164	5	11	406	668
Mozambique	MOZ	49	102	144	253	85	135
Namibia	NAM	61	91	15	27	128	186
Niger	NER	304	631	16	36	927	1518
Nigeria	NGA	800	1697	489	1014	534	1186
Rwanda	RWA	36	62	9	16	171	253
Senegal	SEN	95	167	47	94	135	227
Sierra Leone	SLE	11	22	17	37	16	32
South Africa	ZAF	981	1579	1232	2144	3120	4566
Swaziland	SWZ	19	27	10	16	44	59
Tanzania	TZA	377	758	80	163	1588	2417
Togo	TGO	19	32	34	73	10	18
Uganda	UGA	180	317	171	310	1158	1721
Zambia	ZMB	76	142	59	123	93	155
Zimbabwe	ZWE	131	199	93	162	456	775

(Enahoro et al., 2019)

⁷ The following 10 countries of SSA were excluded from the analysis because of either a lack of data and/or a very limited size of their livestock sector: Cabo Verde, Comoros, Djibouti, Equatorial Guinea, Mauritius, Réunion, Sao Tomé and Príncipe, Seychelles, Somalia, South Sudan.

IMPACT Model Net Trade Estimates for Ruminant and Monogastric Meat, Milk, 2010-2030

Country		Ruminant meat		Monogastric meat		Milk	
		2010	2030	2010	2030	2010	2030
1000 metric tons							
Angola	AGO	-97	-231	-234	-476	-108	-320
Benin	BEN	0	-16	-60	-132	-51	-131
Botswana	BWA	17	23	-1	-1	-91	-79
Burkina Faso	BFA	1	-183	15	-14	-46	-196
Burundi	BDI	-1	-20	-1	-18	-9	-44
Cameroon	CMR	11	20	37	81	-32	-86
Central African Republic	CAF	4	-50	5	2	0	-15
Chad	TCD	7	-37	1	-2	3	-35
Congo	COG	-4	-13	-33	-103	-79	-168
DRC	COD	1	-33	-1	-63	0	-5
Eritrea	ERI	8	4	1	0	-18	-71
Ethiopia	ETH	4	115	-6	-23	21	370
Gabon	GAB	-12	-19	-37	-55	-52	-68
Gambia	GMB	-1	-8	-7	-21	-33	-55
Ghana	GHA	-15	-81	-79	-297	-179	-494
Guinea	GIN						
Guinea-Bissau	GNB						
Ivory Coast	CIV	-8	-14	-10	-18	-139	-318
Kenya	KEN	15	-56	1	-29	61	186
Lesotho	LSO						
Liberia	LBR	-1	-7	-19	-97	-18	-56
Madagascar	MDG	8	-16	-1	-57	-41	-278
Malawi	MWI	-4	-40	-4	-38	-33	-119
Mali	MLI	0	-44	-2	-26	-92	-314
Mauritania	MRT	3	10	-5	-12	-89	48
Mozambique	MOZ	-8	-37	-31	-240	-31	-53
Namibia	NAM	27	29	-17	-29	-52	-60
Niger	NER	1	-266	0	-17	-135	-954
Nigeria	NGA	-23	-259	-36	-351	-986	-2550
Rwanda	RWA	-3	-32	-2	-23	-24	-139
Senegal	SEN	-5	-33	-7	-19	-242	-481
Sierra Leone	SLE	1	-1	-4	-14	-16	-43
South Africa	ZAF	-10	113	-213	-243	-134	-205
Swaziland	SWZ	-11	-11	-3	-2	-51	-53
Tanzania	TZA	-7	-100	-8	-79	-160	-1025
Togo	TGO	0	-9	0	-11	-22	-49
Uganda	UGA	-15	-185	-17	-167	-109	-892
Zambia	ZMB	-7	-71	-4	-57	-24	-122
Zimbabwe	ZWE	13	-14	15	25	62	293

Note: Imports = negative values, Exports = positive values
(IMPACT model estimates)
(Enahoro et al., 2019)

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