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AZAGE TEGEGNE AND GETACHEW LEGESE FEYE

Study of Selected Livestock Innovations in Ethiopia



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Abstract

Ethiopia is endowed with significant livestock resources and holds the largest livestock population in Africa, estimated at around 60 million cattle, 60 million sheep and goats, 52 million chickens, 4.5 million camels, 10 million bee colonies and 7.2 million equines. The livestock production and management system in Ethiopia is mainly extensive, where indigenous breeds are kept under low-input/low-output husbandry practices. This study is part of a multi-country African livestock innovation study covering three East and West African countries (Ethiopia, Kenya and Mali) supported by the Program of Accompanying Research for Agricultural Innovation (PARI). The purpose of the study was to provide guidance to policy makers and private and public investors on promising innovations in Ethiopian livestock value chains and their contexts, which could enable transformation of the livestock sector. The study also aimed at providing private and public decision-makers with guidance on investment opportunities building on a review of broad trends of Ethiopian livestock development and in-depth analyses of success stories from selected innovations to encourage wider lesson-learning and knowledge-sharing. The study is based on a desk review of important documents, key informant interviews, consultations with major stakeholders on respective innovations and analyses of official customs data and other data from the national statistical agency of the country. The study focused on four selected livestock innovations: beekeeping, feed production and marketing, integrated feedlot operation and index-based livestock insurance. These innovations were selected at an inception workshop held in Kenya, Nairobi, in October 2019. Results of the study reveal the possibility to increase honey production six fold through improved frame hive, from the current level of 15-20 kg/hive/year to 90-120 kg/hive/year by raising farmers' skill and knowledge on apiary site management, and facilitating access to inputs. On the other hand, an assessment of feed innovations revealed attractive investment opportunities in the harvesting, conserving and proper utilization of crop residues, hay and other feed resources. Harvesting and conservation of crop residues alone can create employment opportunities for over 245,000 youths for two months a year. Investments in industries that produce feed premixes and additives to supply the Ethiopian livestock sector also hold promise, in light of imports over 4,000 tons of these feed ingredients per annum. Investment in integrated feed production, feedlot operation, slaughter and export of beef is also indicated as a promising business opportunity to enhance benefits from the Ethiopian beef industry. Index-based livestock insurance is also found to be a scalable innovation in the Ethiopian livestock industry that can benefit both livestock producers and the financial sector actors. The study has shown adoption and impact, trade-offs/externalities, potential for scaling and broad policy and development implications of all the four selected livestock innovations in Ethiopia.

Keywords: Livestock innovations, beekeeping, feeds, premixes, integrated beef production, IBLI,

JEL codes: O13, O30, O33, Q16

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The late Dr. Azage Tegegne is one of the two authors who conducted this study, but he suddenly passed away upon the completion of the study. Azage was a principal livestock scientist at ILRI. He spent his entire professional life at ILRI serving as an outstanding scientist, project manager and deputy to Director General’s representative in Ethiopia. Azage received his bachelor’s (animal science) and master’s (animal production) degrees from Addis Ababa University’s Alemaya College of Agriculture (now Haramaya University) in Ethiopia and his doctoral degree (animal production) in 1989 from the Graduate School of Tropical Veterinary Science and Agriculture at James Cook University, Australia. Azage authored/co-authored more than 350 scientific and professional articles, including 150 peer-reviewed journal articles. He played an even larger role as a mentor, co-supervising 71 post-graduate students at PhD (17) and MSc/DVM (54) levels enrolled in Ethiopian and international universities. He closely supported the Ethiopian livestock research and extension system and was a founding member of Ethiopian Society of Animal production, Ethiopian Science Academy and several other professional associations. Azage received more than 20 national and international awards over his career, including most recently being bestowed the degree of Honorary Doctor of Science (*Honoris Causa*) in 2012 from Bahir Dar University and the award of Outstanding Alumni from James Cook University in 2013, and an award recognizing his ‘lifetime contribution’ to the Ethiopian Society for Animal Production (ESAP) in August 2019. Azage was a highly dedicated scientist and a person of details. He followed up the status of this work while he was in a hospital in Addis Ababa despite the pain he was going through from his short illness.

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List of Acronyms

AGP	Agricultural Growth Program
CSA	Central Statistical Agency
CRGE	Climate Resilient Green Economy
DM	Dry Matter
ECC	Ethiopian Customs Commission
EEA	Ethiopian Economics Association
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GHG	Green House Gas
GTP	Growth and Transformation Plan
IBLI	Index Based Livestock Insurance
ICARDA	International Center for Agricultural Research in Dry Areas
ICIPE	International Center for Insect Physiology and Ecology
ICRC	International Committee of the Red Cross
ICT	Information Communication Technology
IGAD	Intergovernmental Authority on Development
ILRI	International Livestock Research Institute
Kg	Kilogram
LG	Lowland Grazing
LSA	Livestock Sector Analysis
Masl	Meters above sea level
MOA	Ministry Of Agriculture
MoARD	Ministry of Agriculture and Rural Development
MRD	Mixed Rainfall Deficient
MRS	Mixed Rainfall Sufficient
MT	Metric Tone
NAIC	National Artificial Insemination Center
NAGII	National Animal Genetic Improvement Institute
NDVI	Normalized Difference Vegetation Index
OIC	Oromia Insurance Company
SPS-LMM	Sanitary Phytosanitary Standards and Livestock and Meat Marketing
TLU	Tropical Livestock Unit
TSI	Total Sum Insured
SNNPR	Southern Nations Nationalities and Peoples' Region
UK	United Kingdom
USA	United States of America
USAID	United States Agency for International Development
USD	United States Dollar
YESH	Young Entrepreneurs in Silk and Honey

1 Introduction

1.1 The livestock resource base and production systems

Agriculture plays a major role in the lives and livelihoods of most Ethiopian people. According to the FAO (2018), the sector employs about 12 million smallholder farmers and 12 to 15 million pastoral and agro-pastoral communities and accounts for about 95% of agricultural production, 85% of all employment and 90% of total export earnings, as well as contributes to 45% of the Gross Domestic Product (GDP). The livestock sector is estimated to account for 10% of the GDP and provides employment to over 30% of the agricultural labour force. Livestock also contributes to about 11% of all formal export earnings. However, when informal cross-border trade is considered, the contribution increases to about 24% (Behnke & Metaferia, 2011).

Four livestock production systems can be broadly distinguished and include a) pastoral and agro-pastoral; b) mixed crop-livestock; c) small-scale urban and peri-urban; and d) large-scale commercial systems. Mixed crop-livestock farming is dominant in the highlands and midlands, while pastoral and agro-pastoral systems dominate the lowlands. In the mixed crop-livestock system, livestock play a central role in the livelihoods of millions of farmers and serves multiple household-level needs. Livestock provide most of the needed draught power for about 80% of farmers who use animal traction to plough their crop fields (Behnke & Metaferia, 2011). Livestock also provide nutritious food, a source of cash income and wealth accumulation, transportation, manure for fertilizing the soil and fuel for cooking. They also serve as a coping mechanism against shocks and as a store of value in the absence of formal financial institutions and functional markets. The arid and semi-arid lowlands, which are home to pastoralists and agro-pastoralists and cover about 78 million ha (61-65 % of the total land area), are home to 12% of the human and 26% of the livestock population in Ethiopia (Bruke, 2003). These areas receive low and erratic rainfall with high temperatures and are extremely vulnerable to land degradation and cyclic droughts. They also support a wide range of biodiversity by hosting many endemic animal and plant species. In these systems, livestock represent the sole means of livelihood (Negassa et al., 2011).

Ethiopia is endowed with huge potential livestock resources and holds the largest livestock population in Africa, estimated at about 60 million cattle, 60 million sheep and goats, 52 million chickens, 4.5 million camels, 10 million bee colonies and 7.2 million equines (CSA, 2018). The livestock production and management system is mainly extensive, where indigenous breeds are kept under low-input/low-output husbandry practices. A livestock sector analysis (LSA, 2014) identified three major livestock production typology zones (Figure 1), which are the lowland grazing (LG, including pastoral and agro-pastoral systems), highland crop-livestock mixed rainfall deficient (MRD) and highland crop-livestock mixed rainfall sufficient (MRS). In general, the livestock production system is subsistence-oriented and productivity and overall production are very low. Only 15% of local cows in the herd are milked, with a daily milk yield of about 1.5 kg per cow. Lactation yields range from 300 to 600 litres per cow per year with an average lactation length of 180 days. Regarding meat production, carcass weights are generally low at about 110 kg for cattle, 11 kg for sheep and 10 kg for goats. The offtake rates are 9% for cattle and 21% for sheep and goats. The total livestock resource distribution by livestock production systems is shown in Figure 2. The specialised production systems include dairy, cattle-fattening and poultry. The lowland grazing areas are home to all camels and a sizable population of goats (70%) and sheep (42%).

Figure 1: Map of major livestock production zones in Ethiopia (MRS, MRD, and LG)

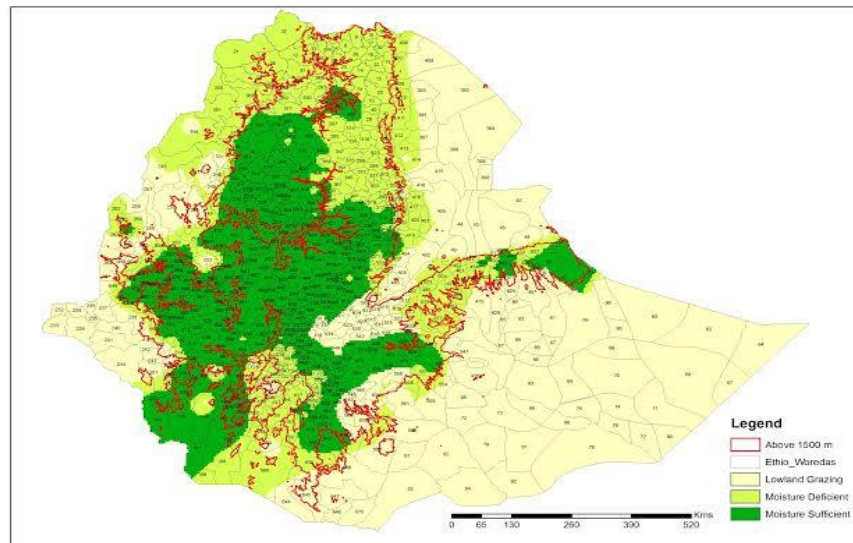
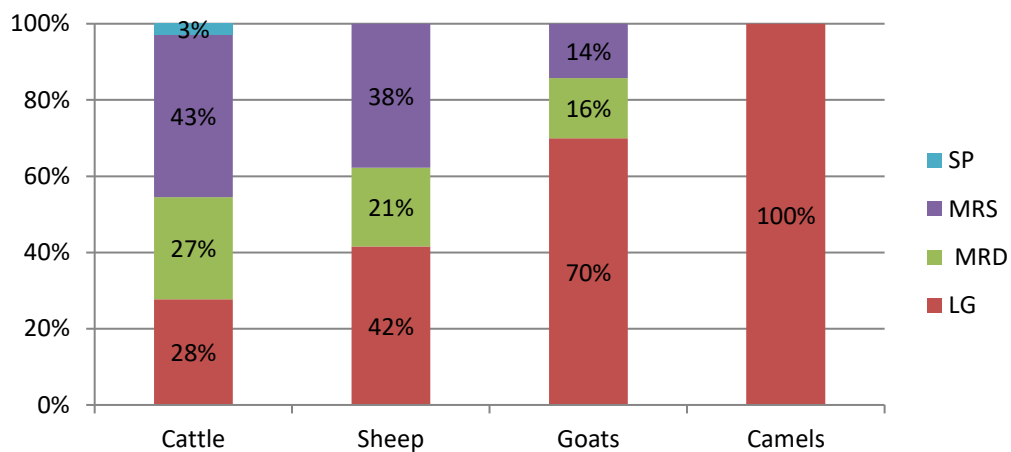


Figure 2: Percentage distribution of livestock by major production systems



(SP - Specialized Systems; MRS - Mixed Rainfall Sufficient; MRD - Mixed Rainfall Deficient; LG: Lowland Grazing Systems)

Source: Shapiro et al., 2015 (for Figures 1 and 2)

1.2 Purpose of this study

This study is part of an African livestock innovation study covering two East African countries (Ethiopia and Kenya) and two West African countries (Mali and Benin). The study starts from the premise that animal source foods will be in high demand on the African continent over the upcoming decades as driven by population growth, urbanization and economic development. The study seeks to provide guidance to policy makers and private and public investors on particularly promising innovations in African livestock value chains and their contexts, which could enable a transformation of the African livestock economy when taking into account their multiple trade-offs and co-benefits. The study also aims to provide private and public decisionmakers with guidance on investment opportunities building on a review of broad trends of African livestock development and more-in depth analyses of success

stories from selected innovations to encourage wider lesson-learning and knowledge-sharing. This document focuses on the review of selected livestock innovations in Ethiopia that can be scaled up in Ethiopia as well as other African countries.

1.3 Selection of innovations

1.3.1 Characteristics of the innovations

Identifying innovations was an important challenge considering the four African countries studied have different livestock innovations with high potential for scaling with some public and private investments. The first task of the study team was therefore to set up the criteria for selecting the innovations to be included in this study at an inception workshop carried out in Nairobi in October 2019. Considering the diversity of livestock resources and their associated innovations in the four countries, the study team agreed to select innovations based on the following criteria:

The innovations should:

- Address the complexity and trade-offs involved with livestock development, including livelihoods, youth employment, nutrition, health, environment, climate change
- Deal with technical, institutional, and political innovations
- Deal with multiple commodities and farming systems
- Deal with value chains, both forward and backward linkages
- Deal with the enabling environment
- Focus on forward-looking trends and new opportunities
- Deal with concrete examples that have achieved a certain scale

1.3.2 Initially proposed innovations for Ethiopia and Kenya

After setting up the selection criteria for agricultural innovations to be considered in this study, the study team split into two groups, the East and West African countries, to identify innovations within their respective regions. Accordingly, the East African team came up with the following list of innovations for Ethiopia and Kenya:

- i. Feeds: Development of hay and crop residue value chains in Kenya and Ethiopia
- ii. Feeds: Youth involvement in livestock sector in Kenya and Ethiopia
- iii. Policy change in export of oil crops and consequent impacts on domestic feed market in Ethiopia
- iv. Genetics: Community-based genetic improvement in livestock (Sahiwal, Small ruminant) in Kenya and Ethiopia
- v. ICT: I-COW (Kenya) and Africa Dairy Genetics Gain (Ethiopia)
- vi. Insurance: Managing of risks in the livestock sector in Kenya and Ethiopia
- vii. Market Integration: Pork (Kenya) and Beef (Ethiopia) value chains
- viii. Poultry cold chain development (Ethiopia)

1.3.3 Prioritized innovations to be studied in Ethiopia and Kenya

Given the limited time available for the study, the team prioritized the following four innovations for the two countries:

- i. Feed: Hay and crop residue value chains
- ii. Youth employment in apiculture value chain development
- iii. Managing Risks: Index Based Livestock Insurance (IBLI)
- iv. Market integration in beef value chains (Vertical integration)

1.3.4 Study approach

This study is based on stakeholder consultations, key informant interviews, analysis of data on potentials and trends and a review of the literature. A one-day stakeholder consultation involving 14 participants was conducted in the first week of November at the ILRI campus in Addis Ababa, Ethiopia. Participants were drawn from the Ministry of Agriculture, the Ethiopian Agricultural Transformation Agency, (ATA), the International Centre of Insect Physiology and Ecology (ICIPE), ILRI, ACIDI/VOCA, private-sector operators in the beef export sector and the Ethiopian Veterinary Drug and Animals Feeds Administration and Control Authority. The consultation forum provided very useful inputs for the case studies on different innovations. The team also conducted key informant interviews with actors in vertically integrated beef operations, IBLI, and the apiculture development and feed sectors. Eight key informant interviews were conducted in October and November 2019.

Secondary data were collected from the Ethiopian Customs Commission (ECC), Central Statistical Agency (CSA) and IBLI Ethiopia. These data were systematically cleaned (particularly the data from ECC) and analysed. The report structure is based on the outline agreed upon during the inception workshop in Nairobi, Kenya.

2 Overview of the Ethiopian Livestock Industry

2.1 Livestock production

2.1.1 Cattle

About 99.4% of the cattle population consists of the local Zebu breeds. The overall number of dairy animals is low and is estimated at around 1 million. The predominant cattle breeds include the Borana, Fogera, Horro, Begait, Sheko, Abigar and Afar breeds. European breeds, especially Friesian and Jersey, have been imported for many years and crossbred with the indigenous breeds to improve milk production (Tegegne et al., 2006). Most of these types of animals are found in urban and peri-urban areas. About 25% of cattle aged between 3 and 10 years is used for draught purposes. Only a fraction of the cattle population (0.72%) is reared exclusively for meat production. The number of cows that are primarily kept for milk production is estimated at 6.3 million or about 14.6% of the total cattle population.

2.1.2 Sheep and goats

Almost all of the sheep and goat breeds are indigenous. Sheep breeds include the Horro, Menz, Bonga, Arsi and Black-Head Ogaden, Bagait and Afar breeds. Some of the major goat breeds include Afar, long and short-eared Somali, Abergelle, Begait and Hararghe Highland goats (Tegegne et al., 2006). Some crossbreeding has been taking place between the Awassi and the local Menz sheep in the North Shoa Zone of Amhara Region. Diseases affect the sheep and goat population. Young stock morality is also high. Meat production is generally low. Sheep and goat breeds recently introduced for crossbreeding with local breeds include the Dorper sheep and Boer goats.

2.1.3 Poultry

Out of the total population of 57 million chickens, 95.9% are indigenous breeds in the hands of smallholder farmers. Only 2.8% and 1.4% of the chicken population are hybrids and exotic breeds, respectively (CSA, 2017). The number of chickens per rural household is small and ranges from 7-10 (Tadelle & Ogle, 2001). These chickens are kept under the traditional scavenging system with little inputs for housing, feeding or health care. Annual egg production from local hens under farmer management ranges from 53 to 60 eggs per hen. Total egg production is very low at about 162 million per year (Halima, 2007). As a result, per-capita egg and meat consumption are low and estimated at 1 and 0.5 kg, respectively.

Although the majority of chicken resources are in the hands of smallholder farmers, three broad production systems can be distinguished. These are a) village/backyard poultry production; b) small-scale commercial poultry production in urban and peri-urban areas; and c) large-scale commercial poultry production mainly developed around Addis Ababa and regional cities. In addition to these systems, the extension system has been involved, for a long time, in the distribution of exotic chickens to smallholder farmers through the regular program as well as various projects with the objective of improving household food security, nutrition and income (Fesseha et al., 2010).

2.1.4 Apiculture

Beekeeping is an integral part of the agricultural economy of Ethiopia. The dominant type of beekeeping is traditional forest and backyard (95.7%), followed by transitional beehives (1.3%) and frame/modern beehives (3.3%). Variations in agroecology and the presence of rich biodiversity favor the existence of diverse honeybee flora and large numbers of honeybee colonies in almost all regions of Ethiopia. There are five different types of honeybees dispersed across the country. The country has

about 10 million bee colonies, 6.3 million beehives and over 800 bee forage plants. Ethiopia is fourth in the world in terms of beehive population, behind India, China and Turkey. It also stands ninth in the world and first in Africa in honey production and first in Africa and third in the world in beeswax production. Although current annual production is limited to 47,706 tons of honey and 5,542 tons of beeswax, the country has the potential to produce 500,000 tons of honey and 50,000 tons of beeswax per year (Kenesa, 2018). Other bee products such as pollen, propolis and bee venom have not yet been commercialized. Ethiopia exports honey to countries such as Sudan, Norway, Saudi Arabia, UK, Yemen, Japan and the USA. Between 2008 and 2011, Ethiopia exported 7,068 tons of honey and 6,752 tons of beeswax. Exports then increased to 4252.8 tons of honey in the year 2011-2016. Currently, exports have reached up to 9,000 tons per annum (Kenesa, 2018).

2.1.5 Fishery

Fish and fish products are valuable sources of protein and essential micronutrients for balanced nutrition, health and income. In Ethiopia, over 200 fish species representing 12 orders, 29 families and 70 genera have been identified. The most important species, which constitute large proportions of commercial catches, include Tilapia, African catfish, Nile perch, Bagrus species, Barbus species and the common carp. The catch data from major water bodies indicate a fivefold increase in the last decade and report 51,000 tons of fish production in 2015/2016. The fishery sector contributes to the economic advancement of fishermen in the local market. For example, 38,000 tons of fish harvested in 2014 generated over 4.0 billion Birr (EIAR, 2017).

2.2 Consumption of livestock products

Livestock production and growth rates are very low and lag behind human population growth. The result is a decline in per-capita consumption of livestock products. Per-capita consumptions of milk, meat, egg, fish and honey are very low and estimated at 19 litres, 8 kg, 1.23, 0.25 kg and 0.29 kg, respectively (Tegegne et al., 2006). The annual per-capita consumption of meat is 43% below the African average. To reach this level, the country needs an additional output of 378,000 tons, which would increase the present annual requirement to 508,778 tons of meat. Furthermore, an additional annual increment of 3% (15,263 tons) is expected to meet the demand of the growing population. Projections of consumption to 2028 show sharp increases in demand for animal products due to rapid increases in population growth and rising per-capita income. Consumption of red meat is expected to grow by about 276%, from 775,000 tons in 2013 to 2.9 million tons in 2028, with an average annual meat consumption of 24.5 kg per year. A red-meat deficit of about 1.3 million MT or 53% is expected. Consumption of milk is also projected to grow by 127%, from about 5 billion litres in 2013 to 11 billion litres in 2028. Domestic milk production is expected to cover more than 71% of the total consumption requirement, leaving a production-consumption gap of 3.2 billion litres (Shapiro et al., 2015).

2.3 Contributions of livestock

2.3.1 Economic

Livestock production contributes to household income and nutrition. Livestock keepers get most of their income from cattle. For instance, in the moisture sufficient production system (MRS), 88% of households get most of their livestock income from cattle. Livestock in MRS contributes 21–44% of total household income, 2–13% of household protein requirements and 4–7% of calorie requirements. Total net household income per capita varies from USD 198 in sheep-dominant households to USD 665 in cattle-dominant ones. In the MRD and LG systems, 85% and 68% of households get most of their

livestock income from cattle, respectively. Total net income of household per capita varies from USD 127 to USD 587 in MRD and USD 51 (sheep dominant) to USD 535 (camel dominant) in LG. Total net income from cattle-dominant households in LG ranges from USD 153 in small pastoral households to USD 272 in medium pastoral households with an average cattle herd size of 7 (LSA, 2014).

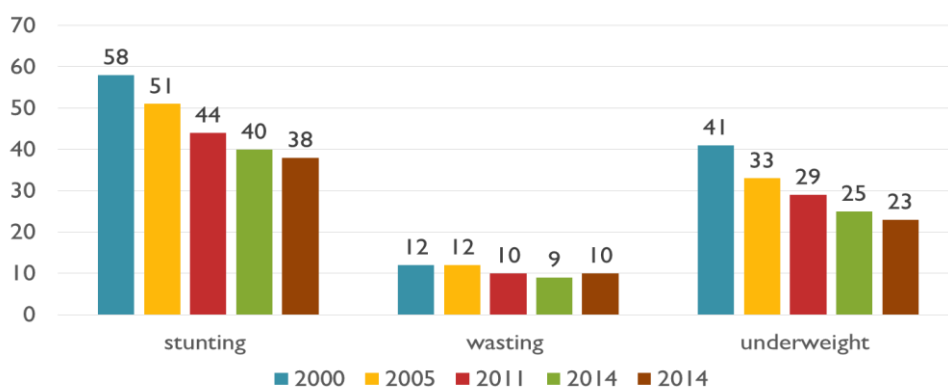
2.3.2 Value addition

Livestock value chains also make significant contributions to the national economy through value-added processing and marketing. The value-added contribution is estimated at USD 1.8 billion (LSA, 2014). With Ethiopia's rising incomes and urbanization, major investments in value-adding will be an important opportunity for the sector. The total contribution of livestock production and processing and marketing, both monetary and non-monetary, to the national economy amounts to about USD 9.44 billion, or 21% of GDP (LSA, 2014). The direct contribution of livestock to GDP is estimated at USD 7.33 billion per year, which amounts to 17% of GDP and 39% of the agricultural GDP. This rises to about 21% of the national GDP and 49% of the agricultural GDP if the contribution of processing and marketing (USD 1.85 billion) is considered. If the indirect contribution to organic fertilizer and traction (USD 1.91 billion) is taken into account, the contribution of livestock to GDP would rise to 25.3%.

2.3.3 Food and nutrition security

Undernutrition, particularly at an early age, can result in mental impairment, intelligence loss and reduced educational capacity and productivity. A study by WFP (2013) on the cost of hunger in Ethiopia indicates that a loss of \$4.8 billion USD or ETB 55.5 billion (16.5% of GDP) in 2009 was due to malnutrition, absenteeism, reduced physical capacity and increased healthcare costs. In 2011, about 44% children were chronically malnourished and stunted, 10% were wasted (acute malnutrition) and 29% were underweight, the highest being in Amhara (52%), followed by Tigray (51%), Afar (50%), SNNPR (44%) and Oromia (41%). As a major source of protein, the contribution of livestock in reducing stunting and malnutrition is substantial. Significant reductions in stunting, wasting and underweight have been observed from the year 2000 to 2014 (Figure 3). The current prevalence of stunting is still above 38%, affecting more than 6 million children. Ethiopia's target is to reduce the prevalence of stunting to 26% by 2020.

Figure 3. Trends in child stunting, wasting and underweight in Ethiopia (2000-2014)



Source: Development Initiatives, 2017

2.3.4 Crop production and soil fertility

In the mixed crop-livestock system, the most important service provided by livestock is animal power for ploughing, transport and haulage. About 80% of Ethiopian farmers use animal traction to plough their crop fields. The value of animal draught-power input into arable production is about one-quarter

(26.4%) of the value of annual crop production. Based on these figures, nearly a third (31%) of the total gross value of livestock output is represented by the value of animal draught power as an input in crop cultivation, an estimated 22 billion ETB (2.17 billion USD) in 2008-09. The value of dung produced by livestock-keeping households was estimated at 3.43 billion ETB (339 million USD), of which dung valued at an estimated 1.4 billion ETB (138.4 million USD) was used by producer households for soil fertility and fuel, while the remaining 2 billion ETB (197.7 million USD) worth of dung was marketed (Behnke and Metaferia, 2011).

2.3.5 Export market

The livestock marketing system in Ethiopia is dominated by informal markets. Cattle, sheep, goats and camels are important commodities that contribute to live animal exports. Meat, skins and hides are also export commodities, though their full potential has not yet been realized. As reported by the Ethiopian Revenue and Customs Authority (2017/2018), livestock and their products, mainly live animals, skins and hides, meat and meat products, and leather and leather products represent important export commodities, preceded only by coffee, oil seeds, gold, and chat (*Catha edulis*) in order of their importance. During the same reporting year, livestock and livestock products contributed to about 9.1% of the country's total export earnings, with a value of about 182 million USD. However, the value of the official trade in meat and live animals is a small fraction of the value of unofficial cross-border live animal exports. The Ethiopian Sanitary and Phytosanitary Standards and Livestock and Meat Marketing Program (SPS-LMM) estimates that the value of the unofficial cross-border trade ranges from USD 250 to USD 300 million per year. Ethiopia also exports small quantities of milk and milk products mainly to neighbouring countries. Between 2005 and 2009, Ethiopia exported milk and butter worth USD 343,000. The country has great opportunity and potential to develop its dairy sector for both the domestic and export markets.

2.3.6 Job creation, youth and women empowerment

Developing livestock value chains creates huge opportunities for job creation, particularly for youth and women. For example, an estimated 750 to 900 million people globally live on dairy farms. In Ethiopia, over two-thirds of the labour requirement for livestock herding in traditional smallholder mixed farming systems and urban and peri-urban dairy systems is provided by children. Women are also involved in the management of farm animals, milk processing and marketing. Labour use in milk processing and marketing activities in different production systems in Ethiopia totalled an equivalent of 174,000 full-time jobs in 2004 (Haile, 2009). Assuming 224.5 persons/jobs per 1,000 liters of milk and 5 billion liters of annual milk production, the dairy sector could create an estimated 1.125 million full-time jobs. Similarly, the Ethiopian Ministry of Livestock and Fisheries (2009) reported that 10.04 million improved-breed chicken were distributed to 894,863 beneficiary households (48.4% of which being female-headed households), which created 355,921 jobs for youths.

2.3.7 Implication on the environment

The mixed crop-livestock production system in the highlands of Ethiopia comprises 40% of land area and 88% of the human and 74% of the tropical livestock units (TLU) of the country. Livestock production in the rangelands/grazing systems and mixed crop-livestock production systems are characterized by multiple uses, users and trade-offs. In the mixed crop-livestock system, draught power is an important input in crop production and crop by-products serve as livestock feed, while manure from livestock is used as organic fertilizer; hence, livestock play a central role in nutrient-cycling. The environmental services provided by livestock include supporting rangeland productivity, nutrient-cycling and soil fertility enhancement, carbon sequestration and preservation of wildlife and other forms of biodiversity including animal genetic resources. However, negative impacts of livestock-environment interaction are also observed, such as the spread of zoonotic diseases, overgrazing, land degradation, GHG emissions and deforestation.

The rangelands are diversified, and livestock production in these areas is based almost exclusively on rangelands with no or limited integration with crop production and relies little on external inputs. Of the total livestock population in Ethiopia, about 27% of cattle, 66% of goats, 26% of sheep and 100% of camels are raised in the rangelands (EEA, 2005). The rangelands are also rich in mineral, water and energy resources, medicinal plants, cultural heritages, socio-anthropological values and other benefits. Different management interventions are required in both production systems to ensure a sustainable production system and tackle land degradation with proper stocking rates, land uses and appropriate nutrient management strategies. For example, light or moderate grazing by livestock increases rangeland/grassland productivity, increases the survival of certain plant species and enhances landscape-level diversity.

2.3.8 Manure production and utilization

The average daily manure production by livestock in Ethiopia (kg DM per TLU/day) is estimated at 3.3 for cattle, 2.48 for sheep and goats, and 2.40 for equine. More than 80% of the manure produced comes from cattle. Under an extensive production system, most of the manure is disposed-off on grazing lands. In the mixed crop-livestock system, manure is collected and used as fertilizer in crop fields or dried and stored for use as cooking fuel (Abebe, 2012).

2.3.9 Ecosystem services

The diverse natural vegetation (leguminous woody vegetation, perennials and annuals) and availability of long and deep-rooted grasses in the Ethiopian rangelands, coupled with the willingness of the government to promote indigenous resource management, positions the country with a large potential to benefit from carbon financing through enhancing soil carbon in the reduction of CO₂ and other gases (Abule and Alemayehu, 2015). Grazing by itself facilitates excrement decomposition through the effects of grazing and animal trampling (Schumann et al., 1999). Furthermore, proper management of rangelands to enhance carbon stock and productivity is one of the national priorities in the CRGE strategy of the Ethiopian government (CRGE, 2011). A study in the Borana area of Southern Ethiopia showed that enclosures have higher carbon sequestration potential than communal rangelands (Bikila et al., 2016). Improving the herbaceous layer cover through a reduction in grazing and woody encroachment restriction are also key strategies for climate change mitigation in the semi-arid rangelands.

2.4 Major challenges of the livestock sector

The constraints that hinder livestock development can be broadly categorized into environmental, technical, infrastructure, institutional and policy. Technical constraints in livestock production include poor nutrition, high prevalence of diseases, poor genetic resource improvement and management and poor market infrastructure. Other factors constraining livestock development in the country include inadequate resource allocation to the sector, lack of suitable institutions and inappropriate development policies.

2.4.1 Feeds and nutrition

The main feed resources are natural pasture and rangelands, crop residues, improved forages and concentrates. Population growth, land degradation, shrinkage of communal grazing areas in the highlands, poor range management and shortage of land for forage production have affected livestock production in the country. Despite past and current efforts made to popularize and disseminate improved forage technologies, the vast majority of smallholder farmers do not use cultivated forage as important sources of feed for their livestock. After five decades of research and extension efforts,

smallholder farmers are still looking for distribution of forage seeds free of charge and are not cultivating improved forages on large plots to obtain significant economic return from their animals. As a result, most parts of the country are deficient in feed supply. Inadequate supply of feeds for the existing livestock population, poor quality of the available feed resources, seasonal variation in availability of feeds and water shortages are the main factors that contribute to the low production and productivity of livestock in the country.

2.4.2 Animal health

The widespread prevalence of a wide range of diseases and parasites in all agro-ecological zones of the country causes direct economic losses through high mortality and morbidity and contributes to the poor productive and reproductive performance of the animals. The annual mortality of livestock is estimated at 8-10%, 14-16% and 11-13% for cattle, sheep and goat, respectively (Shapiro et al., 2015). Young stock mortality is even higher than these estimates. The existence of endemic diseases in the country and poor animal health coverage have affected the export market performance of the sector. Animal health problems that contribute to the low productive and reproductive performance of livestock include an absence of proper disease control measures, lack of movement control, inadequate veterinary services, a shortage of vaccines and veterinary drugs and supplies, weak regulatory institutions and inadequate resource allocation.

2.4.3 Animal genetics and breeding

Although Ethiopia possesses a large livestock population with genetic diversity, its productive performance is low. These livestock resources are used for multiple purposes and have excellent adaptive traits. However, low genetic potential for productive traits limits their overall production. Genetic improvement work has been mainly limited to dairy cattle improvement through artificial insemination under the leadership of the National Artificial Insemination Centre (NAIC) of the Ministry of Agriculture. Some efforts are also being made by International Centre for Agricultural Research in Dry Areas (ICARDA), ILRI and the national and regional agricultural research institutions to promote community-based breeding programs (CBBP) in sheep and goat breeds in different parts of the country. There have also been limited and unsustainable animal genetic improvement programs in beef cattle, sheep and goats, poultry and camels. In addition, traditional livestock-keeping, uncontrolled breeding and the absence of record-keeping for different species of livestock have hindered efforts to undertake a systematic and organized genetic improvement program in the country. In recognition of the importance of genetic improvement, the Ministry of Agriculture has recently upgraded the NAIC to a National Animal Genetic Improvement Institute (NAGII) with the mandate to lead and coordinate national animal genetic improvement programs in Ethiopia.

2.4.4 Processing and marketing

Livestock and livestock product processing and marketing, as a pull factor, are important components of the livestock value chain development. Livestock product processing is limited to a few milk-processing plants and abattoirs. Livestock markets are not well developed and organized. Marketing channels are very long, involving several intermediaries, and the profit margins to producing farmers and pastoralists are small. There is a weak regulatory body that enforces quality and safety standards on live animals and animal products. Live animal exports are often affected by weak sanitary and phytosanitary standards, lack of traceability and prevalence of different diseases from trade. Informal cross-border marketing of many live animals affects the performance of the sector. The lack of an organized market information system, the absence of stock routes with appropriate resting, feeding and watering facilities, the absence or shortage of a specialized transport system for both live animals and animal products, poor market infrastructure, multiple taxation, weak marketing institutions such as marketing cooperatives and the lack of animal welfare regulations all affect the performance of livestock marketing. In addition, inadequate facilities for animal product processing, a shortage of

appropriate livestock product-processing technology and a shortage of properly trained personnel have hindered the adding of value to livestock resources.

2.4.5 Shortage of inputs and services

There is a shortage of inputs in terms of technology and services required for the development of livestock. The introduction of appropriate technology will not yield satisfactory results unless it is augmented with inputs that include genetically improved animals, fodder and concentrate feeds, a steady water supply, veterinary drugs and equipment, forage seeds, as well as equipment and utensils for livestock production and processing. Poor advisory services, a lack of market information, weak involvement of the private sector, and poor vaccination and animal health services have also hindered the development of the sector.

2.4.6 Shortage of properly trained human resource

There is a chronic shortage of properly trained manpower in the field of animal sciences and veterinary sciences. With few exceptions, practical training at all levels is too weak to provide adequate services to producers and processors. There are limited and relevant short-term targeted trainings to upgrade the skills of professionals. Most research and development institutions are not adequately staffed and lack updated knowledge in disseminating appropriate technology. High staff turn-over and frequent restructuring of institutions have also negatively affected the sector.

2.4.7 Inappropriate extension system

The national extension system has been mainly geared towards servicing the subsistence farming system in the crop sector. Although the government has allocated large numbers of development agents, including livestock experts, at the village (rural Kebele) level, their capability, capacity and effectiveness in handling a market-oriented form of livestock development is limited. Most farmers and pastoralists do not have adequate access to inputs and services. The key roles of the extension system as a knowledge broker, facilitator, capacity developer and regulator are too limited to bring about transformational change in the livestock sector. As the agricultural extension package programs have been largely crop-focused, the low participation of farmers in livestock development services shows the need to revisit and re-orient the extension system in order to bring about impact at scale.

2.4.8 Lack of reliable and complete statistical data on livestock

There is no accurate data on the number of livestock resources and the contribution of the sector to the national economy. This affects proper planning and resource allocation to the sector. Data generated by the Central Statistics Authority (CSA) based on sample surveys often do not include pastoral, agro-pastoral and urban livestock resources. Different institutions also produce contradicting figures. Lack of reliable and consistent data has often undermined the livestock resource base and its contributions to the national economy, which has hindered appropriate resource allocation to the development of the sector.

2.5 Outlook for the livestock sector

2.5.1 Development programs

The livestock sector in Ethiopia provides an opportunity for further development of the overall agriculture sector through stimulating overall economic growth, reducing poverty and achieving food security. Activities in the sector have grown since the government started encouraging local and

foreign private investments in ranches, meat-processing companies and abattoirs. Despite some improvement in recent years, especially in terms of aggressive policy and strategy on the export of livestock and livestock products, the sector remains underexploited.

Several factors influence the livestock sector both positively and negatively. Demand for animal products and services will continue to increase in Ethiopia. One of the major drivers of change in Ethiopia is related to its demography. Demographic factors play an important role. The human population, currently estimated at 110 million, is growing at an unprecedented rate. About 65% of the human population is young, or below 25 years of age. The urban population at regional, zonal and districts levels is growing at a rate of 3.5%. The country is recognized as having one of the fastest growing economies in the world with a two-digit growth rate, which has also resulted in increasing incomes. Infrastructure development in terms of roads, railway, air transport, telecommunication, ICT, universities, etc. has improved significantly, opening and connecting the rural parts of the country.

The Government of Ethiopia recognizes the livestock sector as one of the country's key economic resources. The government's policy aims to increase livestock production and productivity, improve livelihoods for farmers and pastoralists and encourage value-added meat exports over live animal exports. The government has created conducive policies and strategies and an enabling environment to enhance investment in and development of the sector. Some positive developments include the establishment of a State Ministry under the Ministry of Agriculture, development of the agricultural growth program (AGP), the implementation of the growth transformation plan (GTP), the development of agro-industrial parks, initiating the climate resilience and green economy (CRGE) strategy, the approval of a livestock breeding policy and the establishment of the National Animal Genetic Improvement Institute (NAGII). Moreover, the existence of a large labour force, suitable agroecosystems, a long culture of livestock-keeping by the community and favourable investment opportunities will serve as assets in the investment in livestock. In addition, global and sub-regional export market opportunities will create opportunities for further development of the sector.

The Ministry of Agriculture, in collaboration with the International Livestock Research Institute (ILRI) and other stakeholders, prepared the Livestock Sector Analysis for the period ending in 2028 and a Livestock Master Plan (Shapiro et al., 2015) to enhance endeavours in livestock development. The LMP is a series of five-year development implementation plans or 'roadmaps' to be used to implement the Growth and Transformation Plans (GTPs). Under the GTP II, the livestock and fishery sector aim to achieve the following major objectives: a) reduce poverty; b) achieve food and nutritional security; c) contribute to economic growth (GDP); d) contribute to exports and foreign exchange earnings; and e) contribute to climate mitigation and adaptation (MoA, 2015).

The LMP sets out investment interventions in better genetics, feed and health services, which, together with complementary policy support, could help meet the GTP II targets by improving productivity and total production in the key livestock value chains for poultry, red meat, milk and crossbred dairy cows. If the proposed investments totalling 7,762 million Ethiopian birr (USD 388.1 million), with 57% and 43% respectively coming from the public and private sectors, were successfully implemented, they could eliminate poverty in approximately 2.36 million livestock-keeping households by helping family farms move from traditional production to market-oriented systems. Beyond this impact on rural people, the anticipated transformation of the livestock sector has the potential to positively impact urban consumers through lower prices on animal products. The success of the LMP is critical in the achievement of food and nutrition security at household, sectorial and national levels.

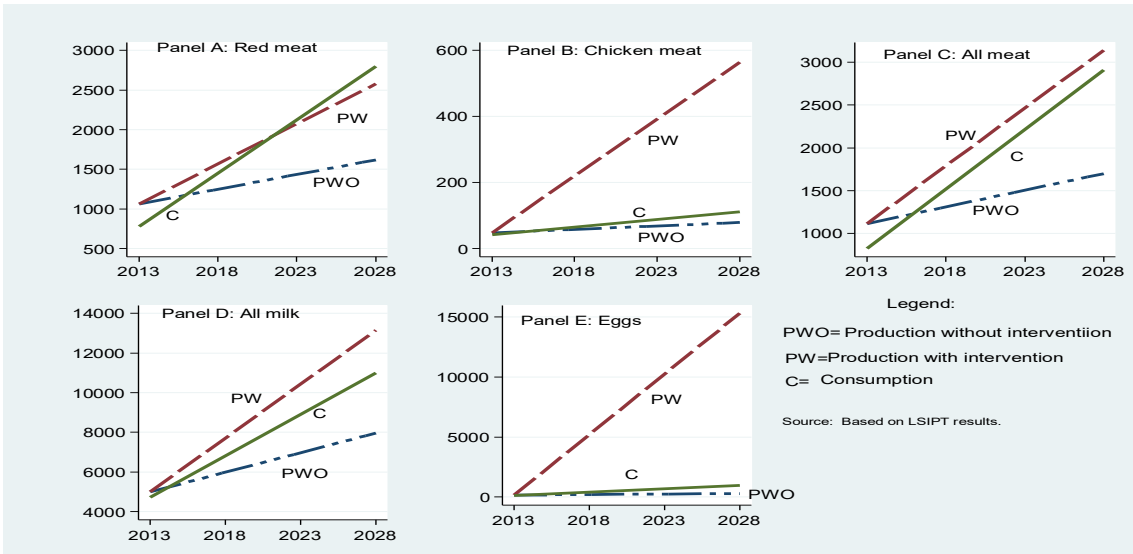
The government has also developed the Climate Resilience and Green Economy (CRGE) Strategy directed at reducing greenhouse gas (GHG) emissions. Ruminant livestock are major producers of GHGs. Under business-as-usual conditions, the large cattle population in Ethiopia is projected to increase from the current 60 million to 90 million by 2025, which would result in a huge increase in GHG emissions. Realizing the importance of ruminant livestock in GHG emissions, the government has planned to arrest the cattle population. Proposed approaches include increasing productivity through

genetic improvement, improving feed resource development and feeding systems, improving animal health and management and implementing the recently approved agricultural mechanization policy and strategy, which plans to replace at least 50% of the current 14 million oxen used for ploughing cropland with machines.

2.5.2 Production and consumption

The demand for meat and milk is mostly met by domestic production. Demand for red meat (beef, sheep, goat and camel meat) is projected to grow by about 276% from 775,000 tons in 2013 to 2.9 million tons in 2028. Due to this sharp increase in demand, a huge deficit of about 1.3 million (53% MT) of meat and 3,185 million liters (29%) of milk in 2028 is projected. Per-capita meat consumption would increase to 24.5 kg/year. To close the projected demand-supply gap, a shift from red meat to poultry consumption will be essential. Investment in the poultry sector would result in a projected surplus of 8% or 181 thousand tons of meat in 2028. A similar pattern is also observed for the projected future production and consumption of milk. The consumption of milk is projected to grow by 127% from about 5 billion liters in 2013 to 11 billion liters in 2028. Domestic milk production is expected to cover about 71% of the total consumption requirement, leaving a milk production-consumption gap of 3.2 billion liters. With appropriate investment interventions, however, it is projected that a 20% surplus of about 2 billion liters of milk will be produced by 2028. This projected surplus of milk could only be realized through investments in better genetics and feed and health services to improve both traditional dairy farms, as well as specialized commercial dairy production units. Production-consumption gaps in meat and milk from 2013 to 2028 are shown in Figure 4.

Figure 4. Projection of demand and supply of livestock products (2013-2028), with and without interventions



Source: Shapiro et al., 2015

2.6 Opportunities for development of the livestock sector

Ethiopia has a large livestock population with considerable untapped potential to contribute to the economic growth of the country. Livestock are kept by smallholder farmers and pastoralists across the country. There is a large resource of genetic diversity across species of animals that are adapted to the different agroecosystems, ranging from arid lowlands in pastoral areas to cool tropics as high as 4,500

meters. The country also has a large human population with significant proportions of young people. The culture of livestock rearing and consumption of animal products among its people is a great advantage for investment. The large human population is a huge market opportunity for the sector, with the potential to create jobs of various natures, particularly for the youth and women, across the livestock value chains. Development of the sector also has huge potential to transform the overall agricultural sector.

There is a need to bring about attitudinal change at all levels to ensure the sector gets the proper attention it deserves. The generation and application of appropriate technologies in livestock management and production, an efficient and effective input supply system, the improved management of livestock and the allocation of adequate resources in education, research and development are critical. In addition, the development of suitable market infrastructure, extension and advisory services, credit facilities, incentives, value-adding and efficient market institutions are key interventions to exploit the potentials of the livestock sector. Enhancing the important role of the private sector in production, the supply of inputs, services, processing and marketing is also key to unlocking the potential of the sector. A fundamental change in production systems is also required in both mixed crop-livestock and pastoral and agro-pastoral systems to enhance the performance of the sector and its contributions to the economic development of the country. These will require key policy and institutional interventions that consider alternative modalities for the development of productive and sustainable production systems.

3 Livestock Innovations

3.1 Apiculture

3.1.1 *Potential for apiculture development in Ethiopia*

Beekeeping in Ethiopia is an ancient tradition that stretches back into the millennia of the country's old history. Indeed, there is no segment of the Ethiopian population that does not share this historical technology. Beekeeping is an important activity for many rural people and is also carried out in homesteads in all parts of the country. It is one of the most widespread practices in farming communities and is a traditionally important off-farming activity for an estimated 1.7 million rural households (MoARD, 2007). Honey and beeswax also play a big role in the cultural and religious life of the Ethiopian people. This historical and traditional knowledge can serve as a springboard in disseminating latest technologies, as disseminating a familiar technology is more likely to be easier than disseminating an entirely new technology.

Ethiopia has huge potential for beekeeping because of its favourable climate for different vegetation, which are very good sources of nectar and pollen for honeybees. Ethiopia is endowed with botanically diversified honey and honey forage plant species that supply ample food to honeybees. A bimodal type of rainfall creates favourable conditions for harvesting honey more than twice a year. As indicated in section 1.2.4, over 800 bee forage plants have been already identified in Ethiopia. Ethiopia is endowed with over 10 million honeybee colonies (MoARD, 2007), out of which about 6.3 million (CSA, 2018) are estimated to be hived, while the remaining exist in the wild and have large production potential. Moreover, five wild honeybee species have been identified to have very huge potential for future apiculture growth in the country. Research has also identified over 16 mono-floral honeys and various multiflora honeys in Ethiopia that can easily be developed into specialty honeys.

The government of Ethiopia is committed to transforming the apiculture sector, as reflected in the background papers for the Livestock Master Plan document and the second Growth and Transformation Plan. The government of Ethiopia has planned to increase honey yield per harvest from frame hives from 20 kg in 2014/15 to 30 kg by 2019/20 and production of honey from 60,700 tons in 2014/15 to 123,900 tons in 2019/20. Moreover, the government has aimed to increase beeswax production from 5.7 thousand tons in 2014/15 to 8.6 thousand tons by the end of the planning period (2019/20). In addition, the government has built the capacity of agricultural extension experts to realize its ambition of agricultural transformation. The most important indicators for this move are the deployment of over 60 thousand agricultural extension agents engaged in crop, livestock and natural resource management extension services and the establishment of over 11,000 farmer training centres. Building the capacity of farmers through training and demonstration of different improved agricultural technologies and practices is one of the strategies being used. Harnessing the potential of the apiculture sector is therefore a matter of enabling extension agents with technical skills and knowledge in improved apiculture innovations.

About 28% of the Ethiopian population (29.1 million) is young (aged 15-29 years). Since most of this labour force is unemployed, there is a huge potential to deploy this potential workforce in the development of the apiculture sector. Since youth in general are acquainted with ICT and can be reached via social media and other electronic media, it will be easier to disseminate information on apicultural innovations using channels such as WhatsApp groups, short message services, interactive radio and others.

3.1.2 *Honey production and productivity in Ethiopia*

Ethiopia has huge honey production potential, and currently ranks first in Africa and tenth in the world in honey production. However, this potential is not practically utilized, mainly because the sector is

considered supplementary to other agricultural activities and has a low level of utilization of modern production technologies. Table 1 shows the number of different types of beehives in Ethiopia.

Table 1: Number and proportion of different types of beehives in Ethiopia

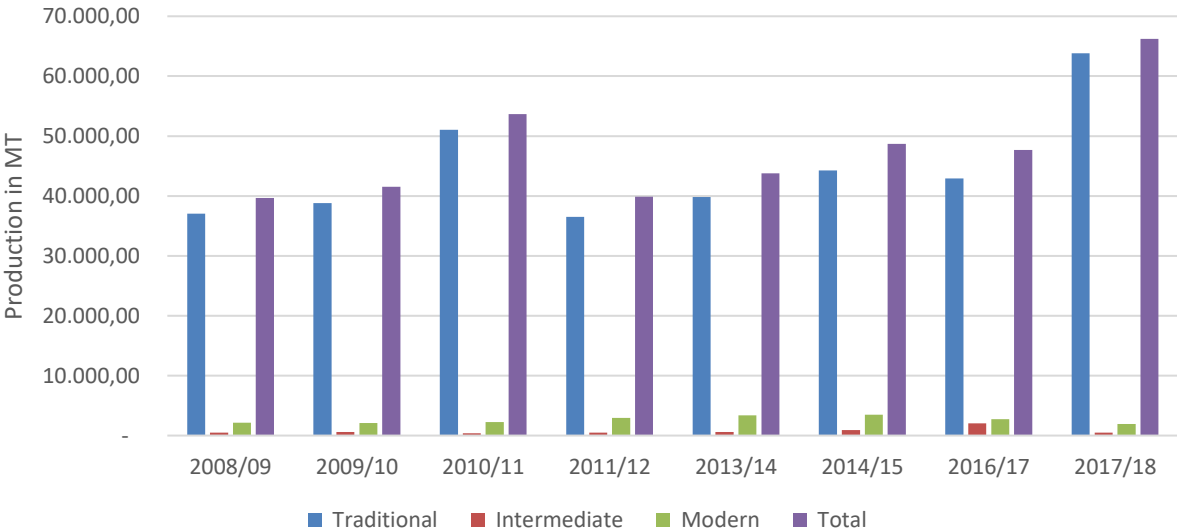
Year	Total number	Traditional		Intermediate		Frame	
		Number	% of total	Number	% of total	Number	% of total
2008/09	5,149,244	5,013,849	97.4	34,552	0.67	100,843	1.96
2009/10	4,598,226	4,447,011	96.7	33,151	0.72	118,064	2.57
2010/11	5,130,322	4,944,380	96.4	41,684	0.81	144,258	2.81
2011/12	4,993,815	4,772,537	95.6	81,965	1.64	139,682	2.80
2013/14	5,052,297	4,768,103	94.4	47,749	0.95	236,446	4.68
2014/15	5,885,263	5,663,492	96.2	71,900	1.22	149,871	2.55
2016/17	6,189,329	5,902,624	95.4	80,832	1.31	205,873	3.33
2017/18	6,523,969	6,327,197	97.0	69,399	1.06	127,373	1.95

Source: CSA (various years)

As indicated in Table 1, about 97% of beehives are still traditional hives and have not shown any changes over the last eight years. There is a very low level of utilization of intermediate (1%) and frame hives (2%) (CSA, 2019). Moreover, technologies in improved apiary site development and beehive management have not been widely adopted. Owing to these and other challenges, the productivity of beehives is very low, estimated at 6 kg/hive/year for traditional hives and less than 20 kg/hive/year for modern (frame) hives.

Ethiopia produces about 66,000 tons of honey a year (CSA, 2019). As can be seen from Figure 5, about 96.3% of the total honey production is obtained from traditional hives. The honey produced from intermediate and frame hives respectively is extremely low and constitute 0.8% and 2.9% of total annual production in 2018.

Figure 5: Honey production in Ethiopia, by beehive type



Source: Author’s calculations based on CSA data (various years)

Apart from the total production figures indicated in Figure 5, it is important to see the productivity per hive in order to understand the potentials for growth using improved apiculture innovations. Despite the government’s ambitions to increase honey productivity per modern hives to 30 kg in 2019, evidence from CSA (2018) shows that it is still 15 kg/hive, which is half of the government target. The overall national productivity for all hives is 10 kg (Table 2).

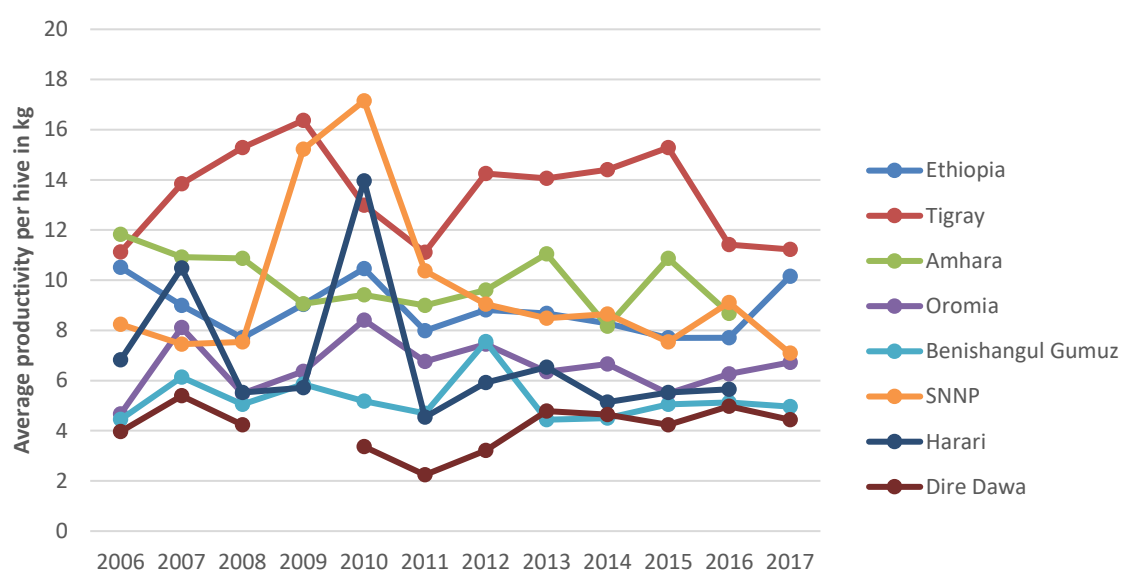
Table 2: Productivity per beehive based on beehive type (kg/hive/year)

Year	Traditional	Intermediate	Modern	All hives
2008/09	7.38	14.25	21.25	7.70
2009/10	8.73	17.52	17.88	9.03
2010/11	10.32	9.29	15.70	10.46
2011/12	7.65	5.81	20.96	7.99
2013/14	8.35	12.83	14.20	8.67
2014/15	7.82	12.90	23.38	8.28
2016/17	7.27	25.20	13.32	7.71
2017/18	10.08	7.17	15.12	10.15

Source: CSA, 2018

Further investigation into the causes of low productivity of the Ethiopia beekeeping sector reveals that it is mainly because of weak interventions of the extension service in building the technical capability of farmers. Despite a consistently low honey productivity per hive in Ethiopia over the span of years, there are regional variations in the productivity figures. The important point here is that regional differences do not correspond to the resource potential of each region. It is normal to expect high productivity per hive in regions with high rainfall and abundance of bee forages and lower productivity in those with lower potential areas. However, the opposite has been observed for the last 10 years. This important difference can be observed in the Tigray region, which registered the highest productivity per hive as compared to other regions of the country that have better natural potential for honey production (CSA, various years). Some studies (Tsegabirhan et al., 2015) and our discussion with senior experts in the field indicate that such a difference was due to the level of attention given by the extension systems in the different regions for the sector. Following expert advice, the Tigray regional state gave due attention to the apiculture sector and the extension system worked in developing the skills and knowledge of farmers to improve beekeeping practices. Since Tigray is relatively drier than other regions (SNNPR, Oromia, Benishangul, Amhara, Gambella), the increased productivity in this region can be attributed to the attention given by the regional government to the apiculture sector and the works done to strengthen the beekeeping extension in the region. This shows a huge potential that could be harnessed if similar efforts are made by other regions of the country where there are higher rainfalls and bee forages.

Figure 6: Productivity per beehive by region, Ethiopia



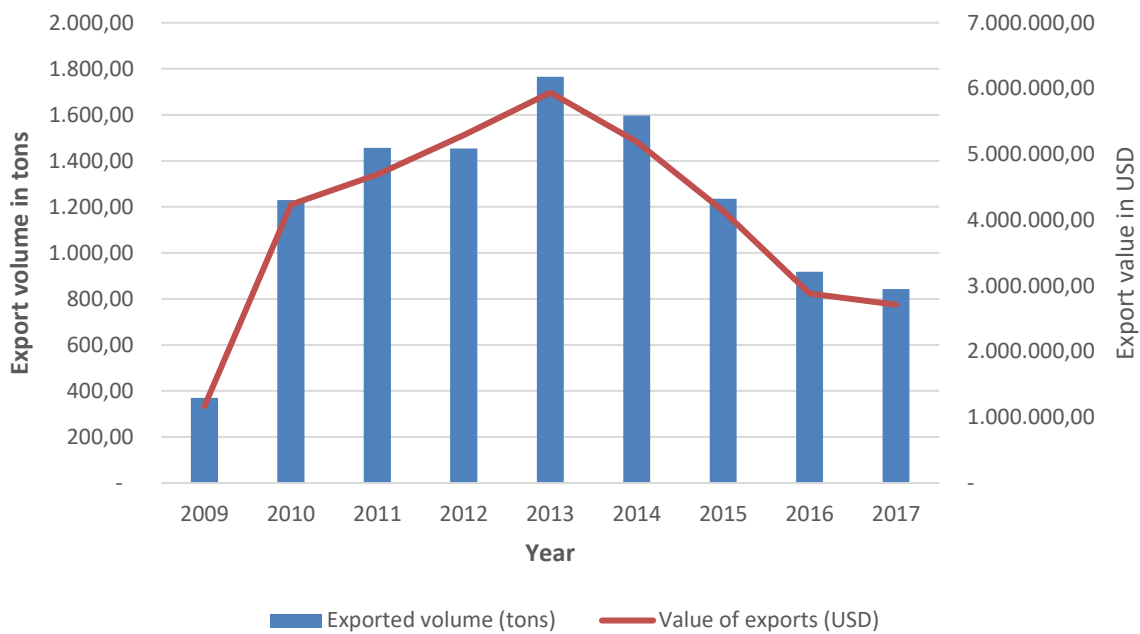
Source: Ethiopian Customs Commission (2019)

Youth employment opportunities in the Ethiopian apiculture sector lie in engagement of the youth in improved (modern) beekeeping innovations after building of their technical, entrepreneurship and financial capacities. This will enable the youth to harness the huge existing yield gap that can be filled with reasonably smaller efforts, since the climate is conducive to the production of bee forages. The existing efforts in soil and water conservation, area closures to rehabilitate degraded lands, production of diverse perennial crops such as coffee and fruit trees and a range of annual crops in the different agroecosystems of the country could support beekeeping initiatives and also benefit from such initiatives through a significant increase in productivity. This implies a significant positive externality of beekeeping in increasing agricultural productivity, enhanced environmental protection, employment generation and poverty reduction. Enhanced youth employment in improved apiculture entails increased production and productivity in beekeeping activity, which directly contribute to the export earnings of the country and promote economic growth.

3.1.3 Export performance

In order to finance its trade deficits, the government of Ethiopia has been promoting export of agricultural commodities. Honey is one of the potential export commodities of Ethiopia (MoA, 2013). In 2017, Ethiopia exported 843 metric tons of honey, which was less than 2% of the total honey produced in the country. The rest of the honey is consumed domestically. About 80% of domestic consumption is used for making *tej* (Ethiopian honey wine). The volume of honey exports reached a maximum of 1,596 tons in 2013 and then declined due to various reasons. The lowest export performance was recorded in 2018 when the country was in the process of political reform and the export sector experienced a general decline (Figure 7). Between 2009 and 2017, honey export volume grew by 11%. The value of honey exports showed a trend similar to the volume of exports (Figure 7). Ethiopia obtained 5.9 million USD from honey exports in 2013, which then declined to about 2.7 million USD in 2017.

Figure 7: Honey export volumes (MT) and values (USD)

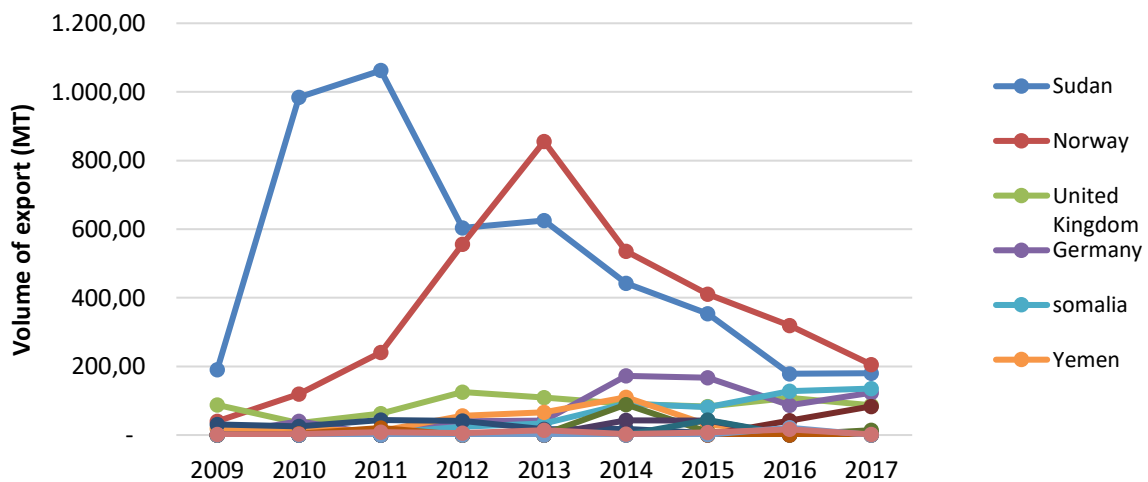


Source: Ethiopian Customs Commission (2019)

Ethiopia is the tenth largest producer of honey globally, but only the 45th largest exporter. Ethiopia is listed as a third country permitted to export honey by the European Commission (COMMISSION DECISION of 11 June 2010, amending the Annex to Decision 2004/432/EC on the approval of residue monitoring plans submitted by third countries in accordance with Council Directive 96/23/EC, notified under document C(2010) 3548 (2010/327/EU)) (Greiling, J. 2008; Gallmann & Thomas, 2012, p.3).

The major importers of Ethiopian honey are Norway, Sudan, Djibouti and Germany in decreasing order (Figure 9). Data obtained from the Ethiopian Customs Commission (2019) reveals that volume of exports to European countries (Norway, Germany, UK, France) and Japan is increasing over time. This is a good opportunity for the Ethiopian apiculture sector, but work is needed on the competitiveness of the sector in order to benefit from the growing market opportunity.

Figure 8: Destinations of honey exports from Ethiopia

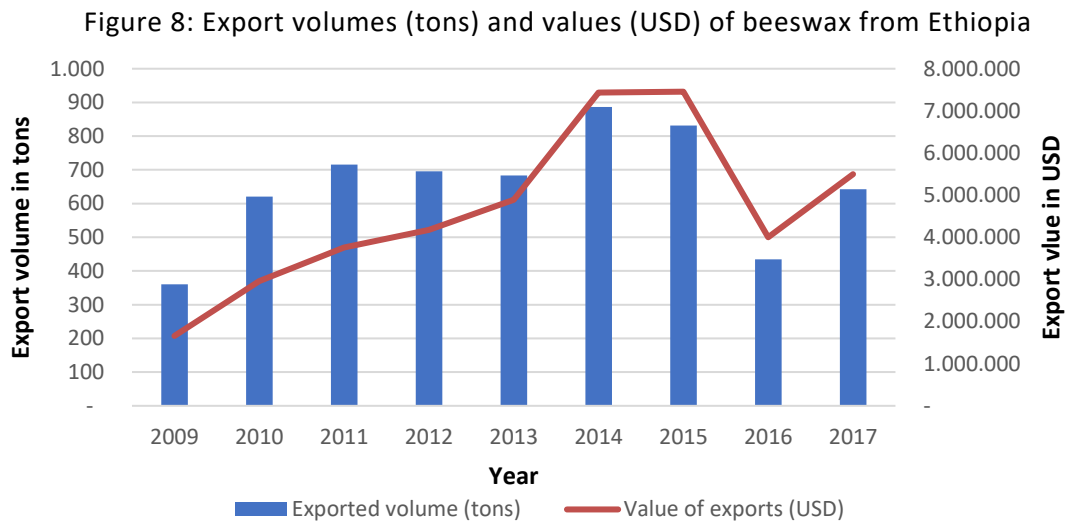


Source: Ethiopian Customs Commission (2019)

As indicated above, the Ethiopian apiculture has several competitive edges that could be developed into speciality honey brands. There are special mono-floral honey types that could be developed into

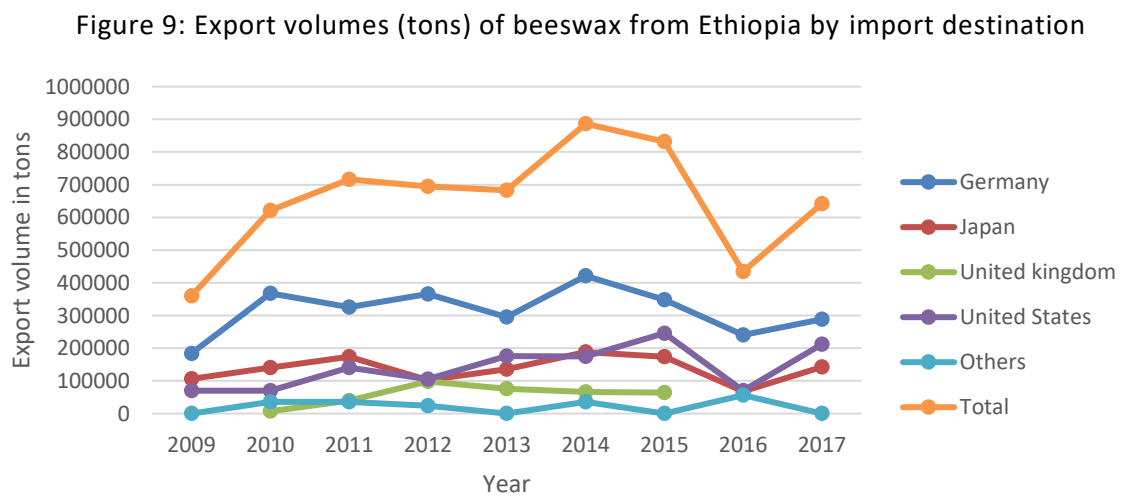
specialty honey. More than 16 mono-floral and various multi-floral honeys have been identified in Ethiopia. *Coffee honey*, *Schefflera abyssinica* (Geteme) honey, *Syzygium guineese* (Walleensu) honey, *Croton Maroschus* (Bakanisa) honey, *Vernonia* (Ebicha) honey, and *Becuin glandiformum* (Tebeb) honey are among the mono-floral honey types identified in Ethiopia.

On the other hand, Ethiopia exported 642 tons of beeswax in 2017 (Figure 8). Like that of honey, the highest export levels of beeswax were reported in 2017. As shown in Figure 8, beeswax export performance followed the same trend as that of honey exports. The major difference lies in the growth rate of export volumes and values. The volume of wax exports grew by 7% while the value grew by 16% between 2009 and 2017.



Data source: Ethiopian Customs Commission (2019)

Germany is the largest importer of Ethiopian beeswax, followed by the United States, Japan and the United Kingdom. Ethiopia exports only 33% of its beeswax (Figure 9). The remaining balance is used domestically for candle making and beekeeping, while about 33% is wasted. This shows the potential to increase wax exports from Ethiopia with some investment in creating awareness and entrepreneurial skill development.



Source: Ethiopian Customs Commission (2019)

3.1.4 Technical and economic analysis of the innovation

As indicated above, Ethiopia has suitable agroecosystems to produce diverse types of bee forages. The bimodal nature of rainfall in most parts of the country makes the production of bee forages easier than any other crop or livestock production activity. Regional differences in productivity per beehive per annum, where a relatively drier region of the country (Tigray) has higher productivity, reveal the underutilized potential in the rest of the regions. The major reason for better productivity in Tigray region is the attention given to the sector by the regional government in strengthening the extension services in beekeeping. This allowed beekeepers in the region to obtain more technical skills and knowledge in beekeeping and management, which resulted in increases in productivity. It is possible to dramatically increase productivity in other regions through better extension services, supply of better-quality frame hives and entrepreneurial skill development.

The global average honey yield per hive per year for the period from 1993 to 2010 was 40-45 kg (Tsegabirhan, et al., 2015). Under this pretext, there are 10 frames in each frame beehive and each frame can produce 3-4 kg of honey. If 50% of the frames are occupied with brood and pollen and only 50% are filled with honey, it is possible to produce 15-20kg per super at a time. If the apiary site is well-developed through strong extension services and the farmer can add one more super per hive, farmers could then obtain 30-40kgs per harvest. The difference in productivity in this case is expected only by improving hive management and putting one more super on each hive. The national average number of harvests a year under the existing traditional production system is twice a year. This means, with two harvests a year, the yield per hive a year could increase to 60-80kg. However, there are areas that harvest at least four times a year (twice after each rainy season due to the availability of bee forages). Assuming that it is possible to harvest 50% of the second harvest in the third and fourth harvests, the yield per hive per year can increase to 90-120kg with four harvests and one super. It is possible to increase yields per hive if farmers get better access to the required quality inputs and the apiculture extension gets stronger in training farmers. If apiary sites are well-developed, especially in high potential areas, it is possible to increase the number of harvests to six times in a year. There are a few exceptional farmers that have already attained this level of productivity. However, this needs to be scaled up to benefit the large number of unemployed youths and the country at large.

3.1.5 Adoption and impact of the innovation

About 96% of beehives are still traditional, and literature shows that the rate of adoption of modern beekeeping technologies is low. However, this does not mean adoption of technologies is low in all parts of the country. The adoption rate is increasing over time in areas where focused interventions are made and farmers/the youth are equipped with the necessary technical and entrepreneurship skills and get access to finance for acquiring modern equipment. Regular technical supervision and support is a crucial success factor. For example, the number of beekeepers who adopted improved technologies has increased and the number of apiary sites, production and productivity have also increased in areas where interventions were made through the Young Entrepreneurs in Silk and Honey (YESH) project that is being implemented by the International Center for Insect Physiology and Ecology (ICIPE). Spill-over effects from beekeeping are expected to increase as a result of such interventions and increased apicultural activities.

3.1.6 Trade-offs/externalities of the innovation

Beekeeping is a business with multiple positive externalities on different sectors of the economy and the environment. Apart from honey production, apicultural innovations have several positive externalities. The most important positive externality of beekeeping is through its pollination activity. Bees are the best pollinators and they help to increase production and productivity of different crops, fruit trees, vegetables, forages and forest trees. Increases in productivity due to crop pollination are presented in Table 3.

Table 3: Productivity gains (%) in different crops due to pollination by honeybees

S.N	Crop type	Increase in productivity (%)	Remarks
1	Coffee	17-39	
2	Sesame	20	
3	Cotton	10	
4	Citrus fruits	7-23	
5	Papaya	10	
6	Niger seed	43	Also increases oil content of the seed
7	Onion seed	84	

Source: Tsegabirhan et al. (2015)

Massive investments are underway in soil and water conservation and environmental rehabilitation in Ethiopia. These consist of area closures, forage and agroforestry measures for soil conservation. Tree planting is also being undertaken on a large scale in Ethiopia in order to implement the Climate Resilient Green Economy strategy of the government. In all these efforts, honeybees play a very important role in the pollination of different plant species and the enhancement of their development. Beekeeping also benefits from such interventions, since the plants serve as bee forages and aid in honey production. Moreover, in communities that benefit from apiculture, people care for trees and bees are considered as a bridge between the current and future generations.

3.1.7 Potential for scaling

Innovations in apiculture are among the most scalable agricultural technologies available due to their low financial and land requirements. The government of Ethiopia is committed to scaling up apicultural development across the country and creating jobs for the youth. Ethiopia has over 29 million youth (15-29 years). Since unemployment among this sector of the population may contribute to political instability, the government strongly supports sectors of the economy that can engage the youth with relatively lower investment.

3.1.8 Lessons learned from application of the innovation

The apiculture sector in Ethiopia is currently dominated by traditional technologies and characterized by low productivity per beehive. Ethiopia has nine regional states and efforts made by the different regions to transform the sector and their natural potential for apiculture vary at large. The beekeeping extension in most of the regions is very weak. As a result, there is a low level of technical skill and knowledge among bee farmers. Lessons from the Tigray region reveal that investments in improving the extension system can tremendously improve productivity per hive (Tsegabirhan, et al., 2015). It is possible to increase productivity by enhancing the capability of farmers in bee management and apiary site development.

3.1.9 Broad implications

The analysis of apiculture activities in Ethiopia shows that there is a tremendous possibility of increasing productivity by more than 6 times if due attention is given to the sector. Appropriate interventions in the sector could easily triple the current level of production, increase the incomes of bee farmers, create jobs for the youth and significantly support the national economy. The employment generation in apiculture will also contribute to gender inclusiveness, private sector

development and social and political stability in the country, which may even contribute to the stability of the Horn of Africa region.

Relevant Policy Recommendations

- Improve apiculture extension in order to enhance farmers' knowledge and technical skills in apiculture (hive management and apiary site development).
- Regulate the supply of quality apiculture materials: there is a need to inspect the quality of improved hives and related equipment produced and distributed by different entities.
- Entrepreneurial development: There is a need to change public opinion at all levels on the importance of apiculture development.
- Practice gender inclusiveness in promoting apiculture innovations.
- Develop and implement effective regulatory systems in the apiculture industry to ensure the quality of apiculture inputs and outputs.
- Apiculture is not only about beehive management. It also requires apiary development. There is a need to allocate land for the youth to develop bee forages.
- Develop and implement policies that can reduce the risks and impact of agrochemicals on bee colonies.
- Develop and enforce a road map for apicultural development.
- Support public and private investment in apiculture sector.

3.2 Feeds

3.2.1 Description of the innovation and its contexts

Ethiopia has diverse agroecosystems suitable for production of different kinds of livestock. The country has a huge livestock population, which is first in Africa in terms of headcount. Livestock production supports the livelihoods of millions in agricultural, pastoral and agropastoral societies. According to the FAO (2004), livestock production supports the livelihoods of over 80% of the Ethiopian population and contributes to 15 to 17% of the overall Gross Domestic Product (GDP) of the nation and 35 to 49% of the agricultural GDP. Livestock also accounts for 37 to 87% of rural household income (ibid). Moreover, livestock and livestock products such as meat, hides and skins are the third major export category, accounting for 9.4% of the export revenue (NBE, 2019). However, despite the large livestock resource base and the importance of livestock to the livelihoods of millions of people, the productivity and economic contribution of the livestock sector are below potential due to technical and non-technical constraints (Tolera, 2012). One of the major technical constraints limiting productivity of livestock is the shortage and poor quality of feeds. According to a study conducted by the FAO in 2018 (Table 4), Ethiopia has a deficit of 27 million MT of feed each year and needs to fill this gap in order to ensure feed security.

Table 4: Annual feed balance taking into account actual availability of feed resources (on DM basis) and the competing uses of crop residues and export of oilseeds

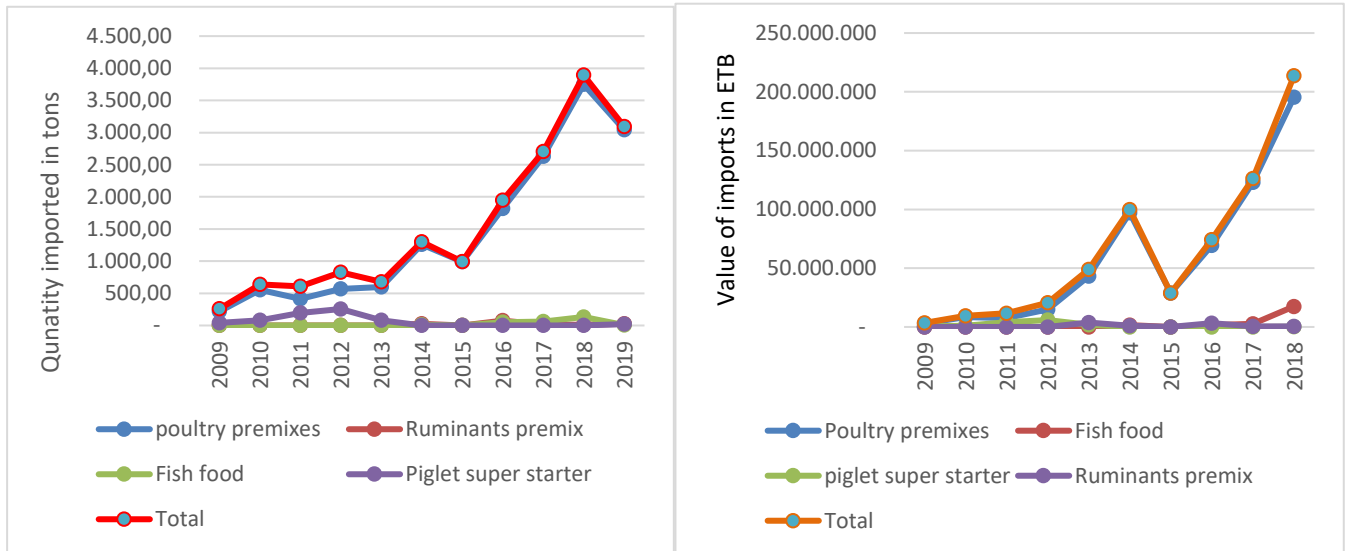
cal	Forages (x10 ³ tons/year)			Permanent crops (x10 ³ tons/year)	Concentrate feeds (x10 ³ tons/year)			Feed availability (million tons/year)	Feed Requirements (million tons/year)	Feed Balance (million tons/year)	Feed balance (Absolute)
	Total crop residue-	Total stubble	Total grazing feed		Oil seed cake	Cereal bran	Pulse by-products				
Tigray	2741	465	4744	1	9	130	8	8	10	-2	-21
Afar	90	15	2800	0	0	4	0	3	4	-2	-35
Amhara	1196	1822	1393	20	107	460	177	28	34	-6	-17
Oromia	1252	2678	2120	258	213	102	202	38	50	-12	-24
Somali	237	38	2744	2	3	11	0	3	2	1	29
B.Gumuz	510	86	2875	3	39	32	3	4	1	2	143
SNNPR	4733	711	6914	784	7	208	98	13	23	-9	-40
Gambela	26	7	1821	0	0	2	0	2	0	1	280
Harari	22	5	17	0	0	1	0	0	0	0	-71
Dire Dawa	40	5	36	0	0	2	0	0	0	0	-56
Total	3289	5832	5708	1069	378	187	488	100	126	-27	-21

Source: Taken from FAO feed inventory study (2018)

The problem of feed shortages is growing with increases in human and livestock population, encroachment of crop farming into grazing areas, increasing incidences of drought in pastoral areas and increasing demand for feed in export markets. These factors have contributed to sharp increases in feed prices, which are also reflected in the increasing prices of meat, milk and eggs. As a result, access to livestock products is becoming limited, particularly for the low-income group of society, which will eventually be reflected in the health and wellbeing of people and low economic productivity of the nation. The high price of feed is also an issue in the competitiveness of meat exports from Ethiopia.

With increasing demand for livestock products and the increasing use of improved animal production practices in dairy, poultry, and fattening, the use of commercial feeds has been increasing in Ethiopia (Tolera, 2007; 2012). The number of feed processing industries has also increased over time. For certain rations, these industries rely on imports of feed additives, pre-mixes and vitamins. In 2018, Ethiopia imported about 4,000 tons of feed premixes and additives (Figure 10). However, with a scarcity of foreign currency in the country and increasing global prices, the supply of these feed ingredients has become a major challenge to the feed industry and is highly manifested in domestic feed prices. During the consultation workshop, government officials and private sector operators suggested that establishing industries that can domestically produce such feed ingredients could be an attractive investment area in Ethiopia. This would be an opportunity to supply feed ingredients to the livestock industry in Ethiopia and other East African countries. This investment could be a growing and sound business opportunity, given the geographical proximity of Ethiopia to these countries and the ongoing efforts to strengthen economic ties among the Intergovernmental Authority on Development (IGAD) countries.

Figure 10: Quantity (Left) and Value (Right) of feed ingredients imported to Ethiopia



Source: Computed from ECC (2019)

In order to reduce the effect of high feed prices on the prices of livestock products and its subsequent impact on the people and the national economy, the Ethiopian government imposed a ban on feed exports in 2008. The ban has been in force for the last 11 years. However, the current government lifted this ban at the beginning of October 2019. The lifting of the ban is opening a window of opportunity for investors interested in the production and export of feed to different neighbouring countries, where the demand is high. The purpose of this study is to provide background information for policy and investment decisions in Ethiopian feed innovations.

Technologies available for scaling in the Ethiopia feed industry are:

- forage varieties to produce cultivated forages
- harvesting, baling and piling crop residues
- haymaking
- urea-molasses treatment of crop residues
- use of effective micro-organisms
- use of industrial by-products

Industry structure of commercial feed sub-sector in Ethiopia

The number of industries operating in the feed industry is a good indicator of industry structure. According to a report by Bediye et al. (2018), a total of 81 enterprises were operating in the Ethiopian feed industry in 2016 (Table 5). These enterprises were grouped under 5 major categories. According to this report, 32 private enterprises and 28 farmers' unions were engaged in the production of compound feeds and 21 private enterprises were engaged in the production and import of feed supplements (premixes, feed additives, etc.). Domestic production of feed supplements is currently limited to mineral supplements and effective microbes, while the delivery of premixes depends on imports. Major categories of premixes include those for egg production (rearing, starter and layer premixes), broiler premix (broiler starter, broiler grower and finisher) and ruminant premix, which contains vitamins, trace elements, minerals and other additives. There were 5 private enterprises engaged in the importing and local manufacture of feed processing equipment and machinery. There was only one formal forage seed production company (Table 5).

Table 5: Industry structure and regional distribution of feed enterprises

Region	Number of enterprises by category					Total number of enterprises
	Feed processing plants	Farmers union	Supplement producers and importers	Feed processing machinery/equipment importers and manufacturers	Forage seed producers	
Addis Ababa	10	1	10	4	1	26
Oromia	12	6	4	1	0	23
Amhara	4	7	0	0	0	11
SNNPRS	4	6	1	0	0	11
Tigray	2	8	0	0	0	10
Total	32	28	15	5	1	81

Source: Bediye et al. (2018)

The regional distribution of the feed industry enterprises is concentrated in Addis Ababa (32%), Oromia (28%), Amhara (14%), Southern Region (14%) and Tigray (12%) (Bediye et al., 2018). In terms of their fields of operation, most private companies are located in Addis Ababa and Oromia regions. For instance, out of 32 feed processing private enterprises, 31% were in Addis Ababa and 38% were in Oromia regional state, while most importing companies (67% of supplement importers and 80% of equipment and machinery importers/manufacturers) were located in Addis Ababa. An even distribution of feed processing enterprises is observed along with farmers' cooperative unions that are established by farmers to address the felt needs of producers in their respective regions. All of the 5 enterprises engaged in the importation or manufacture of feed processing equipment/machinery are located in Addis Ababa. The only formal commercial forage seed producer is also located in Addis Ababa.

Major compound feeds produced by private feed-processing enterprises and farmers' cooperative unions

The major compound feeds produced by Ethiopian feed processing plants and the volume they process are indicated in Table 6. The dominant type of feed processed in 2016 by these plants were poultry feeds. The fact that the government plans to expand the poultry industry and that the associated demand for poultry feed is increasing contributes to this phenomenon. The government plans to substitute red meat with poultry meat, which is indicated in the Livestock Sector Development Master Plan and the Climate Resilient Green Economy strategy. Though the data is slightly outdated, the information in Table 6 shows that poultry feed constitute over 56% of the compound feed produced in Ethiopia. The other important sector that uses compound feed in Ethiopia is the dairy sector. Specifically, the urban and peri-urban dairy sector uses exotic animals that require better feed and other management practices.

Table 6: Major compound feeds produced by private and farmers' union feed-processing plants from September 2015 to August 2016 in tons/year

Feed type	Private processing plants	Farmers' union processing plants	Total	Percentage share of compound feed
Dairy Feed	11920	4156	16076	26.2
Beef cattle feed	3439	5372	8811	14.3
Poultry feed	34362	143	34505	56.2
Other feeds	1929	95	2024	3.3
Total	51650	9766	61416	100
Percentage share	84.1	15.9	100.0	

Source: Bediye et al. (2018)

Price trends of livestock feed in Ethiopia since 2004/05

Price trends of feed ingredients, using 2004-05 as the base year and 2016 for the average price, suggest an average percentage change/increase of 602 % across the 12 years and an annual growth rate of 19 % during this time period (Table 7). The trend in price change can be considered an indicator for the rapidly growing gap between the demand and supply of different livestock feeds leading to skyrocketing prices. The most recent price data in Table 7 is that of 2015/16 and the largest price during this period was that of chicken starter mash followed by grower's mash. This poses a major challenge to the government's plan to expand the poultry sector and increase access to poultry products (meat and egg) for people with low incomes (see section 1.6.2). Investment in the feed industry will be an important intervention to realize the planned development in the livestock sector and ensure better access to animal source foods for consumers.

Table 7: Price trends for concentrate feeds in ETB per quintal

Concentrate/ ration	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2015/16	% change
Layer ration	152	164	179	360	374	380	503	835	449%
Grower ration	147	138	170	357	360	370	552	1027	599%
Chick starter ration	196	169	202	386	420	450	655	1068	445%
Dairy ration	86	108	128	302	230	230	334	611	610%
Calf ration	94	107	136	312	340	350	428	856	811%
Bull ration	88	106	127	301	310	310	300		
Heifer ration	92	114	134	308	320	320	280	644	600%
Cattle ration	83	111	131	305	260	260	352	609	634%
Sheep ration	84	105	125	301	240	260	354	644	667%
Average increase/percentage change									602%
Annual growth rate									19%

Source: Alemu et al. (2012) and Bediye et al. (2018)

We have also tried to determine the price trend in agro-industrial by-products used as ingredients for compound livestock feed in Ethiopia (Table 8). The largest price hike was observed for molasses, followed by oilseed cakes and brans. Such price increases could be the result of competing uses of these products, such as the production of ethanol from molasses (to be mixed with benzene) and the massive export of oilseeds, soybeans and maize grain.

Table 8: Price trends for agro-industry by-products in ETB per quintal

Byproduct	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2015/16	2018/19	% change
Maize 1st grade	117	140	158	560	350	300	400	510	745	537%
Wheat bran	56	63	96	220	130	125	280	417	650	1061%
Wheat middlings	70	76	109	230	170	170	300	420	850	1114%
Nouge seed cake	63	88	170	250	220	220	300	480	1140	1710%
Rapeseed cake	45	50	65	70	75	75	130	290	700	1456%
Soybean meal			450	480	590	600	750	1200	1812	303%
Cottonseed cake	170	175	180	200	214	220	455	500	900	429%
Molasses	5	4	7	7	26	47	47		98	1860%
Average price increase between 2005 and 2019										1059%
Annual growth rate										18%

Source: Alemu et al. (2012), Bediye et al. (2018), and Summary of Telephone interview with stakeholders

3.2.2 Technical and economic analysis of the innovation

The innovations to be promoted in this category are crop residue choppers, baling and storing of crop residues and the production of cultivated forages for both domestic and export markets. These technologies can contribute towards ensuring livestock feed security in Ethiopia and creating youth employment opportunities and business opportunities for the private sector operators. For instance, we have calculated the amount of crop residues that can be produced in Ethiopia per annum using crop production data. We used conversion factors to estimate the amount of crop residues that can be produced from a crop stand that produces a given quantity of grain (Tolera, 2007). Accordingly, based on CSA data on crop production, Ethiopia produces up to 50 million MT of crop residues per annum (Table 9). However, not all these feed resources (crop residues) are properly harvested and conserved for use during the dry season. This may require some interventions in creating awareness and providing training to farmers on proper harvesting, conservation and utilization techniques for these crop residues.

Table 9: Quantity of crop residues that can be produced from different crop species (CSA 2012-2018), in metric tons

Sources of crop residues	2012 (MT)	2013 (MT)	2014 (MT)	2015 (MT)	2016 (MT)	2017 (MT)	2018 (MT)	2019 (MT)
Cereals	35,631,859	36,645,418	39,955,719	43,932,788	43,192,396	47,404,851	50,185,030	43,160,994
Pulses	2,400,061	2,905,261	3,462,732	3,229,209	3,326,342	3,475,748	3,581,860	3,601,518
Oil crops	1,758,036	1,843,741	1,771,103	1,803,534	1,950,215	2,197,486	2,230,806	2,077,043
Total	39,789,956	41,394,420	45,189,553	48,965,531	48,468,953	53,078,085	55,997,695	48,839,555

Source: Authors' calculations, based on CSA annual crop production data (2012-2018)

Based on the experiences of the Improving Productivity and Market Success of Ethiopian farmers (IPMS), project which was led by ILRI from 2004 - 2012, it is possible to build the capacity of the youth and engage them in harvesting, conservation and marketing of crop residues. Manual baling machines that may not require large initial investment can be used in order to address wider areas and engage more people using affordable technologies. This innovation will have multiple advantages, such as job

creation, increase in feed availability and stabilized prices of feed and livestock products. Putting aside the amount of employment that can be created from the chopping of maize, sorghum and millet, we tried to estimate the number of youths that could be employed in baling and the conservation of crop residues. It is estimated that Ethiopia can produce up to 50 million tons of crop residues per annum. Assuming a bale of crop residue weighs about 17 kg and a person can bale 200 bales a day using manual balers (according to personal communication with IPMS team members), baling 50 million tons of crop residues requires 14.7 million man-days. Assuming crop harvesting is an agricultural activity that can run for a period of two months, the baling operation can create employment opportunities for 245,095 youths for two months.

3.2.3 Adoption and impact of the innovations

Different projects have been promoting and supporting forage and feed development in Ethiopia. However, the approach in most of these projects has focused on promoting feed production without considering the marketing aspect. As a result, the promotion of technologies by different projects have not resulted in their wider adoption. Generally, the adoption of improved forages, silage and haymaking and urea treatment of crop residues at the smallholder farmer level is very low (Alemayehu, et al., 2017; Gebremedhin, 2003).

3.2.4 Trade-offs/externalities of the innovation

There are some trade-offs in forage and other cultivated crops production. The major trade-off occurs with food crop production. The general belief is that the production of cultivated forages compromises land to be used for food crop production. However, this does not match concrete evidence on the profitability of cultivated forages and food production on a certain parcel of land. There are limited number of studies conducted on the profitability of forage production in Ethiopia. For instance, Getnet et al. (2016) compared the profit that can be obtained from irrigated Rhodes grass seed production versus traditional irrigated crops. The finding shows the absolute and comparative greater profitability of irrigated Rhodes grass seed. Rhodes grass seed is 4 times, 1.27 times, and 1.25 times more profitable than irrigated barley, irrigated wheat and irrigated tomato, respectively (Getnet et al., 2016). Negussie et al. (2011) also examined the economic benefit of introducing forage legume-cereal intercropping into a traditional mixed-farming system. The results showed that farm income and resource productivity increase in the range of 52-75 % and 10-14 percent, respectively. In addition, soil erosion and the marginal value productivity of grazing land decreases in the range of 8-9 % and 65 percent, respectively. This shows that the production of forages is a profitable business and has positive externality on the livelihoods of farmers and the environment.

3.2.5 Potential for scaling

Given the increasing demand for livestock products and the associated increases in the domestic and export markets for feed, the production of cultivated forages and proper harvesting, baling and conserving of crop residues are highly profitable innovations that could be easily scaled up.

3.2.6 Lessons learned from application of the feed innovation

Lessons from studying feed innovations in Ethiopia are the needs to consider employment generation and profitability of the feed innovation. The innovations should create employment and engage the unemployed youth.

3.2.7 Broad implications

It is possible to overcome the severe feed insecurity problem in Ethiopia through the conservation of crop residues, haymaking and conservation, and the production and proper utilization of cultivated

forages. The diverse agroecosystems of Ethiopia also make it possible to produce cultivated forages, particularly under irrigation, for the export market throughout the year.

3.2.8 Relevant policy recommendations

- Organize the youth in the feed sector, link them with financial support institutions and provide them with technologies such as:
 - balers of crop residues and hay
 - choppers for crop residues such as maize, sorghum, millet
 - mini feed millers for harvesting crop residues
 - Feed mixers
- There are existing technologies in small-scale feed milling and management. To harness this, there is a need to develop good business cases and train youths on their technical, economic and operational aspects (maintenance and profit management of the machines)
- Capacity development on feeds and nutrition (skill training for extension workers and providing them with required technologies)
- Establish stakeholder coordination and synergy on feed enhancement
- Create a workable strategy designed to implement existing policies (seed and feed quality management, marketing etc.)
- Promote large-scale commercial cultivated forage production for both domestic and export markets in order to encourage investment in the feed sector
- Private investors coordination with smallholders (contract farming/use of out growers)
- Provide support for investments and the establishment of premix, feed additive and feed supplement industries in Ethiopia. Such investments will be useful for Ethiopia and East African countries.

3.3 Integrated beef production

3.3.1 Description of the innovation and its contexts

Despite the huge livestock resource endowment, Ethiopia has not adequately exploited the international market and obtained the expected level of benefit from this resource. Taking this into consideration, the Ethiopian government and its development partners have given due attention to the sector and sorted out the major bottlenecks hindering the development of the livestock sector in general, and meat exports in particular, in order to boost the country's meat exports and optimize the associated foreign earnings. Since innovations in integrated beef production are intended to improve the competitiveness of Ethiopia's beef exports, the discussion in this section focus entirely on the beef export value chain.

Production and supply

The diverse agroclimatic conditions of Ethiopia make it very suitable for producing different kinds of livestock. Most of the livestock are produced by pastoralists, agro-pastoralists and smallholder mixed crop–livestock farmers and sold to private entrepreneurs operating in a marketing chain involving collection, fattening and transportation up to terminal markets. In Ethiopia, livestock are kept for multiple purposes, such as sources of draft power, milk, meat, skin and hides. They are also the main source of income and are closely linked to the social and cultural lives of producers. The number of

livestock owned per household varies from location to location depending on diverse agro-ecological conditions and factors like feed availability, disease prevalence and resource allocation. In Ethiopia, cattle, goats, sheep, camel and poultry, in order of magnitude, are used for meat production; however, the first three species are the most common ones. According to a CSA (2018) livestock sample survey, Ethiopia has 60.4 million cattle, 31.3 million sheep, 32.7 million goats and 1.4 million camels. The annual growth of livestock is estimated at 1.2 %for cattle, 1 %for sheep, 0.5 %for goats and 1.14 %for camels, while annual offtake is estimated at 10 %for cattle, 35 %for sheep, 38 %for goats and 6.5 %for camels (Belachew and Jemberu, 2003; Negassa and Jebar, 2008).

Meat production is influenced by livestock population, feed availability, the genetic potential of an animal to convert feed, the off-take rate, and the age and sex of the animal. Taking these variables into account, the Ministry of Agriculture (2009) estimated Ethiopia’s potential for the production of meat at 0.98 million MT. Considering the dynamics of the livestock industry, we have estimated the meat production potential of Ethiopia following a similar approach. Our current estimate is based on the 2018 livestock population data (CSA, 2018). Based on the cattle, sheep, goat and camel population and their respective off-take rates of 10, 35, 38 and 6.5 %nationally and estimated carcass weights of 130 kg for cattle, 10 kg for shoats and 200 kg for camels, we estimate the annual meat production of Ethiopia at 1.04 million tonnes (Table 10).

Table 10: Ethiopia’s Meat Production (carcass weight equivalent)

Type of animals	Total population (millions)	Off-take rate per annum (%)	Estimated carcass weight per head of animal (kg)	Type of meat	Volume of meat that can be produced per annum (million tons)	Share of total production (%)
	(2)	(3)	(4)		(6) = (2)*(3)*(4)	
Cattle	60.39	10%	130	Beef & Veal	0.785	76
Sheep	31.30	38%	10	Mutton and Lamb	0.119	11
Goat	32.74	35%	10	Goat Meat	0.115	11
Camels	1.42	6.5%	200	Camel Meat	0.018	2
Total	125.85				1.037	100

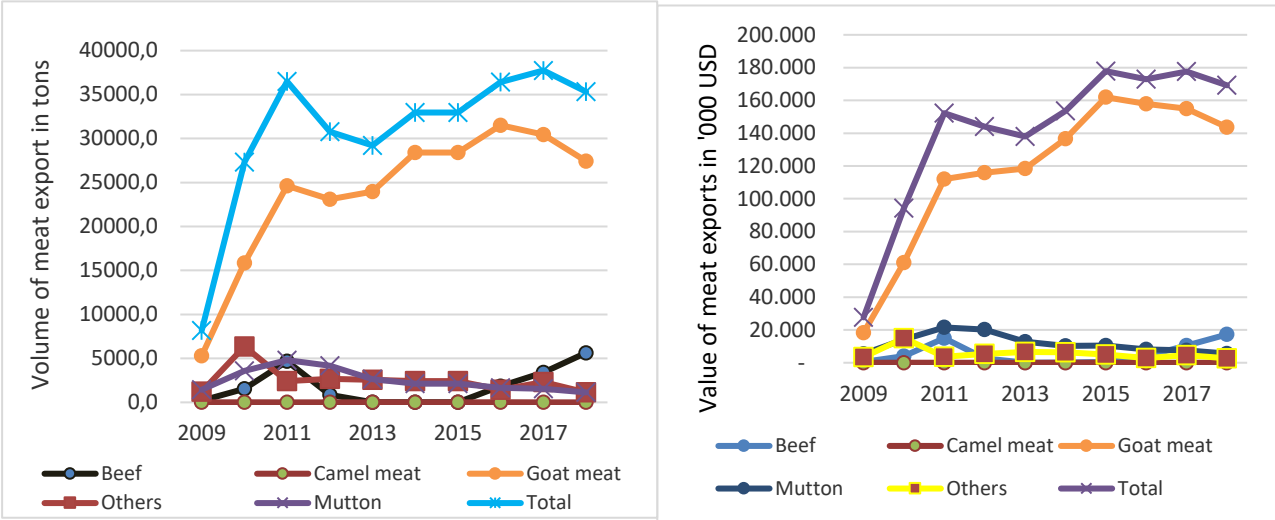
Source: Authors’ calculations, based on CSA (2018) livestock sample survey data, MoA (2009).

As can be seen from Table 10, the majority of meat production potential is expected to be obtained from cattle. However, the current volume of beef exports from Ethiopia is very small. Ethiopia exported about 35,000 tons of meat in 2018. About 78% of this volume was goat meat, while beef only accounted for 16% of total meat exported (Figure 11). Ethiopia exports chilled shoat meat to the Middle East. Beef is not the major meat export of Ethiopia mainly because of the high domestic price of animals and high cost of feeds, which challenges the competitiveness of beef exports. The domestic meat price appears to be very high, especially for beef, and the export market fails to compete for live animals in the domestic markets. The major challenge exacerbating this problem is overvalued Ethiopian currency (Kuma et al., 2015). The government of Ethiopia has taken action to devalue the local currency in order to encourage exports. However, the measures taken at certain points in time could not sustainably resolve this problem, since the currency exchange in the country continued to be determined by the government rather than by market forces (supply and demand). However, companies such as Verde Beef are trying to produce competitive products using a vertically integrated approach. In this approach, the company produces most of the feed used for fattening cattle, collects animals of a specific age and weight from smallholder producers/pastoralists, and feeds them until they attain a target slaughter weight. Animals are then slaughtered, and the beef is exported to different countries. The volume and value of beef exports started rising after the entry of new export abattoirs with a higher capacity to slaughter and export frozen beef and the operationalization of a vertically integrated beef operation like Verde Beef.

As can be seen from Figure 11, goat meat is the largest relative to lamb and beef. This is mainly because of high demand for Ethiopian goat meat in the Middle East.

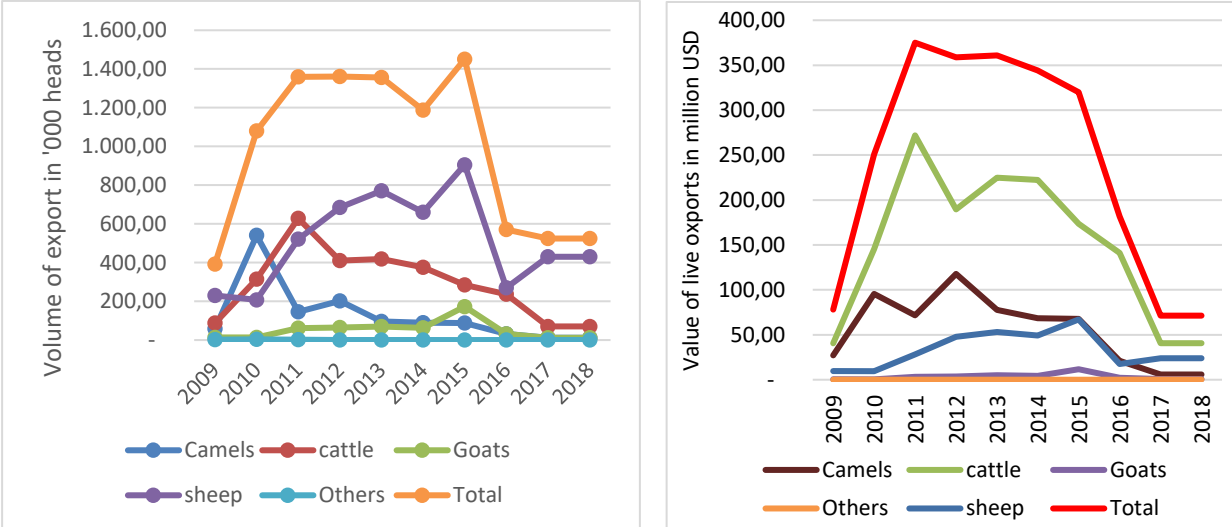
The live animal export trade from Ethiopia is an entirely different one from that of meat exports in terms of the composition of animals in the export channel (Figure 12). In terms of export volume, sheep dominate the live animal export market followed by live cattle and camels. Live sheep export is targeted mainly to the United Arab Emirates for sacrifice during the Arafa season. The highest number of sheep exported from Ethiopia was recorded in 2015, when the country exported over 905 thousand sheep. In terms of value, the most earnings in foreign trade are obtained from live cattle exports due to the higher price of cattle as compared to sheep.

Figure 11: Value of meat exports from Ethiopia in '000 USD



Source: Computed from ECC (2019)

Figure 12: Number (left) and value (right) of Ethiopia's live animal exports



Source: Computed from ECC (2019)

Supply areas

According to the traditional classification of livestock production systems, there are two distinct systems in the country. The highland areas, with altitudes of over 1500 meters above sea level (m.a.s.l), cover 40% of the total area of the country (1.2 million km²) and host about 60% of the total livestock population. On the other hand, lowland areas, whose altitude is below 1500 meters above sea level, cover 60% of the country's land mass. Though the exact number is unknown because of various reasons, Negassa and Jebbar (2008) reported that pastoral and agro-pastoral areas contain 40% of the goat, 40% of sheep, 20% of cattle, and 100% of the camel population of the country. Ayele et al. (2003) also indicated that cattle and sheep are the main livestock in highland areas and camels and goats are the prominent domestic animals in the pastoral lowlands below 1500 meters above sea level. The major pastoral lowland areas are located in four regional states: Somali (44 weredas), Oromia (34 weredas), Afar (29 weredas) and SNNP (6 weredas). These are the major sources of livestock for the export market. In general, the export market sources 90% of the export animals from the lowland pastoral areas of the country.

3.3.2 Technical and economic analysis of the innovation

Vertically integrated beef operations are innovations involving feed production, the sourcing of animals of a specific age and weight from pastoral areas, feeding of the animals (feedlot operation), the slaughtering of animals and the exporting of beef. As per our discussion with stakeholders operating in the feedlot business, the major challenges of vertically-integrated operations are getting access to land for feed production and the high price of feeder animals and the challenge it poses to competitiveness in the export market. Given the time constraint we had in collecting data for economic analysis, we are not able to calculate the profitability of the operation. However, we understood from the consultation workshop that the profitability of an operation depends on access to land to produce feed, since feed costs are the most important component of a feedlot operation. For instance, since Verde beef has larger plots of land for feed production, the company is producing over 70% of its own feed requirements. On the other hand, another private operator, Alana PLC, does not have access to land for feed production and could not sustain its operation to the extent of Verde beef. All other feedlots operating in Adama, Madjo, Adami Tulu and other areas rely entirely on purchased feed. Unlike Verde Beef, these feedlots operators export live animals by conditioning the animals while they go through the quarantine process.

3.3.3 Adoption and impact of the innovation

The idea of vertically integrated beef operations was suggested in 2011 by a USAID funded project and the government of Ethiopia has since been encouraging private-sector operators to participate in such a business. However, given the high initial investment needs of the operation, its large land demand, and its demand for the use of improved and well-coordinated livestock technologies, the only commercial-level operation implemented has been by Verde Beef. This means that the innovation is currently being experimented by Verde Beef and is not widely adopted yet.

3.3.4 Trade-offs/Externalities of the innovation

As indicated earlier, vertically integrated beef operations require getting access to a large area of land for feed production, a feedlot operation and a slaughterhouse facility. It is also suggested to additionally own a ranch to ensure a continuous supply of feeder animals of the required number and quality. Since land in the highlands is occupied by smallholder farmers, availing the required size of land for such operations will have a negative externality on smallholder farmers. However, it is possible to initiate such operations in partnership with smallholder farmers and pastoralists.

3.3.5 Potential for scaling

Vertically integrated beef operations are a scalable innovation the Government of Ethiopia promotes to improve the competitiveness of the beef export sector. The government provides support and encourages the private sector to participate in irrigated agriculture and forage production, which creates favourable conditions for the scaling up of such an operation. The government support includes the duty-free import of irrigation equipment, machinery, import of forage seeds, income-tax-free privilege for expatriates to be hired to support such operations and access to finance. As indicated earlier, the binding condition for wider adoption and scaling of this technology is getting access to sufficient land for the operation.

3.3.6 Lessons learned from application of the innovation

Lessons from the Verde Beef operation show the need to work with the surrounding community. Since such projects rely on the surrounding community for labour and other inputs, it is imperative to include community development and outreach components in the business plans for such projects. The outreach program could be in the form of livestock production and management technologies, veterinary services, out-grower schemes for forage production and a supply of feeder animals.

3.3.7 Broad implications

The broad implications of vertically integrated beef operations are the possibility of developing the Ethiopian beef industry and making it competitive through the integration of different components of the production system. It is possible to align smallholder farmers in the production of forages, supply of feeder animals, feeding and supplying the market with competitive finished animals. Smallholder farmers as well as commercial producers can be linked in the afore-stated areas of operation (ranching, feed production, feeding of animals, export of animals) in such a way that one operator creates a push/pull factor for the other.

3.3.8 Relevant policy recommendations

- Land-use policy: The government should avail suitable land for such operations. However, this should not be at the expense of smallholder farmers or pastoralists. Potential conflicts and the sustainability of a project should be taken into account when delineating investment lands.
- Access to finance: The private sector operating in this area needs to have easy access to finance. This is because the operation is capital-intensive, especially to set up the farm and develop the proper facilities.
- Set up a dependable market information system that is accessible for smallholder farmers and commercial operators.
- Periodic mapping of resources: There is a need to periodically assess the livestock resource base of the country and make location-specific information available to all actors involved in the value chain.

3.4 Index based livestock insurance

3.4.1 Description of the innovation and its contexts

Index-based livestock insurance (IBLI) is insurance against forage scarcity. IBLI insures based on a remotely sensed vegetation index (Normalized Difference Vegetation Index - NDVI) – a satellite-based

indicator of forage availability. It is an “*asset protection policy*” to keep core breeding animals alive during severe droughts when pasture/grazing are depleted. IBLI pay-outs are made once the index threshold is exceeded. Timely pay-outs are made to pastoralists to enable them to purchase resources needed during drought season, such as feed, water, and veterinary drugs. The insurance reduces or avoids the distressed selling of assets.

IBLI in Ethiopia was launched in the Borana Zone in August 2012. Since its introduction, more than 14,000 pastoralists have purchased the insurance. The total sum-insured is Birr 80,780,700 (or about USD 3 million). Oromia Insurance Company (OIC) has been serving as the underwriter of the IBLI product. Five pay-outs have been made so far – the largest being in 2017 (Birr 7 million or about USD 304,337 to more than 2,500 pastoralists) and in 2019 (Birr 5 million or USD 171,306 to 3,000 pastoralists).¹

A range of technical and organizational capacity-building efforts were made that benefited OIC, the National Meteorology Agency, and a host of government and non-government agencies involved in disaster risk financing and management. With an effort to scale IBLI, the International Livestock Research Institute (ILRI) undertook IBLI pre-feasibility studies in Afar and Somali Regional States.²

In Ethiopia, under the leadership of the MoA, discussions are underway to explore options for scaling IBLI within the framework of a broader agricultural insurance policy/program.

3.4.2 *Technical and economic analysis of the innovation*

Insured Value: IBLI covers the four standard livestock types in pastoral herds (i.e. camels, cattle, sheep and goats). For the IBLI asset protection contract, the insured value is the estimated cost of the inputs (feed, water, veterinary drugs, etc.) required to sustain the insured livestock over a given season in a year of severe drought. The following are the current insured values for the different livestock types:

Camel= 5,000 ETB Camel= 3,000 ETB Sheep or Goats = 500 ETB

Total Sum Insured (TSI): This is the total insured value covered by a purchased IBLI policy. For example, if a client purchases a policy for 1 camel, 1 cow and 4 goats, the total sum insured will be ETB 10,000 [5,000 + 3,000 + (500x4)]. TSI is divided into two based on months covering the dry seasons in a year, whereby the long dry season holds 58% of the TSI and the short dry season makes up the remaining 42%.

Premium Rate: The premium rate is calculated as a function of the degree of risk associated with each Insurance Unit. The premium rate is based on a historical assessment of the frequency and level of payment the insurance contract would have paid out in each insurance unit. The premium rate also includes the cost of providing the insurance service. For the 2017/2018 season, the premium rate varied between 7.27% and 11.11% in the Borana Zone Insurance Units.

Annual Premium: This is the amount that the pastoralist/client pays for annual coverage. It is the premium rate multiplied by the sum insured [Premium Rate x Total Sum Insured]. With an annual premium of 8%, the annual premium payment of the above-described pastoralist is ETB 810 [8.10% X 10,000], or the premium rate multiplied by the total sum insured.

Pay-out: In the event the contract is triggered, the pay-out is the compensation that insured clients will receive. The pay-out is a function of the severity of forage scarcity as indicated by the calculated index and the total sum insured of the individual client.

¹ For some more specific information on recent pay-outs, please click on the following link: <http://addisstandard.com/news-drought-hit-borana-pastoralists-receive-insurance-payout/>.

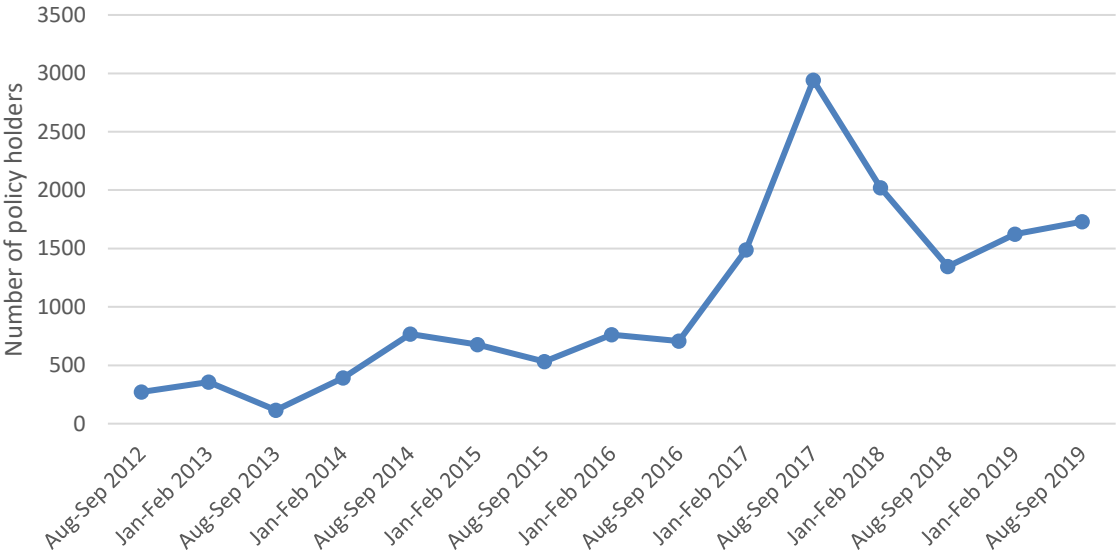
² A high-level meeting aimed at scaling IBLI in Ethiopia and the IGAD region was also held in Addis Ababa. Details of the meeting can be found in the following links: <https://ibli.ilri.org/2018/07/24/its-all-systems-go-for-the-scaling-up-of-index-based-livestock-insurance-in-ethiopia/>, <http://livestockinsurance-igad-conference.org/>.

Minimum Pay-out: is the minimum percentage of total sum insured that will be paid out by the insurance company each season if a contract is triggered. The minimum pay-out rate is currently set at 5% of TSI.

3.4.3 Adoption and impact of the innovation

Since launching in August 2012, the IBLI engagement in Borana Zone has steadily gained momentum over years and reached its height in 2017 (Figure 13).

Figure 13: The number of insurance (IBLI) policy holders since 2013

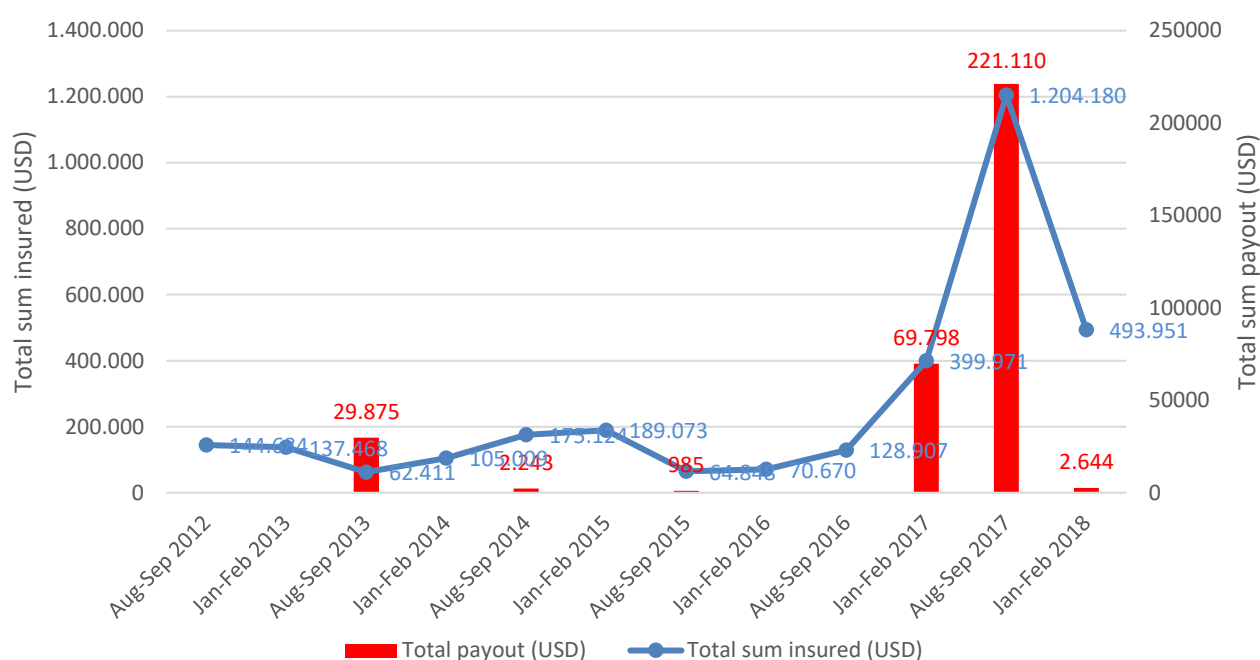


Source: <https://www.researchgate.net/>

Underwritten by the Oromia Insurance Company (OIC), sales have increased over the past years, accelerating in 2017 and 2018 as record indemnities offered clients a clear demonstration of the value of IBLI (Figure 14). The insurance policyholders were pastoralists belonging to medium-to-high wealth category groups. During the first four years of project implementation, even this category of pastoralists insured mainly goats (shoats), the species with the lowest amount of insurance premiums. This was largely a risk-minimizing strategy that pastoralists employed as IBLI was new to them. The species composition has progressively tilted over time towards cattle and to some degree camels after the pastoralists experimented with the innovation and found it useful.

The low uptake of insurance by the pastoral communities was the main challenge during the initial years of the project. This challenge was overcome through investigating insurance cost and incentive mechanisms that can attract more pastoralists and taking concrete measures to overcome the visible challenges. The measures taken include, among others, (i) lowering the costs of administration, raising awareness, premium collection and other such costs of insurance company (ies) through the use of digital technologies; and (ii) instituting smart subsidies that would incentivize poorer sections of the communities to partake in the scheme and richer segments of the communities to insure greater numbers of (high value) livestock. Learning from the upscaling experiences of livestock index insurance in Kenya and the promises IBLI expansion has shown in different parts of Ethiopia where pastoralism is a way of life, ILRI has been involved in providing guidance and technical assistance to pertinent government ministries/regional bureaus so that pastoralist insurance is treated – in practice – as an integral part of Ethiopia’s disaster management and social protection strategy.

Figure 14: Total Insured Sum and Pay-outs (USD) since 2012



Source: <https://www.researchgate.net/>

The highest pay-out was recorded during the 2017 droughts, as a result of which IBLI paid out about USD 69,798 in September 2017 and USD 221,110 in February 2018. ILRI, OIC and a range of partners are building on the experience and knowledge generated from the comprehensive research and development agenda around the IBLI pilot spearheaded by ILRI to support a concrete effort to scale the IBLI provision sustainably to other areas of Ethiopia in which pastoralists vulnerable to drought-shocks can also benefit from IBLI coverage.

3.4.4 Trade-offs/externalities of the innovation

IBLI has both positive and negative externalities. The positive externality is the containment of the potential effects of drought on the pastoral community, enabling pastoralists to avail the necessary inputs ahead of time before the drought becomes severe. It reduces the burden of commercial destocking. This has huge positive contributions to the economy. The negative externality of IBLI could be soaring input prices impacting neighbouring livestock-keepers when pastoralists enter input markets with money injected from IBLI pay-outs.

3.4.5 Potential for scaling

IBLI is proven to be a scalable product. In Kenya in 2012, IBLI began to scale beyond a pilot site in *Marsabit* district into *Isiolo* and later *Wajir*.

In Ethiopia, the amount of IBLI purchases within Borana Zone has increased progressively. In collaboration with the International Committee of the Red Cross (ICRC), preparations are underway to introduce IBLI to pastoralist households in East Hararghe Zone, Oromia Region.

The prefeasibility studies in Afar and Somali regions have also shown IBLI's replicability there.

3.4.6 Lessons learned from application of the innovation

The lessons learned from application of IBLI are the possibility of saving livestock, the main source of livelihood for pastoralists, by monitoring feed availability.

3.4.7 Broad implications

The government and its development partners spend huge amounts of money on commercial destocking during drought seasons and the rehabilitation of pastoral communities after drought. Channelling these financial resources to strengthen IBLI and supporting the pastoral community to buy insurance premiums is a wise investment and creates a win-win situation for all parties involved in such initiatives.

3.4.8 Main operational challenges

- Lack of effectively organized intermediaries between underwriters and policyholders.
- Low affordability of the insurance premium cost.
- Poor financial literacy level of pastoralists.
- Poor insurance participation of pastoralists during good seasons.
- Poor infrastructure services (e.g., telecommunications/mobile reach, roads).
- Limited human/institutional capacity in the design, development, operationalization, and monitoring of index-based insurance in Ethiopia among key players/actors in the insurance industry.

3.4.9 Key policy/regulatory and institutional challenges

- Absence of an enabling regulatory framework for micro-insurance. For instance, there is no regulation that would encourage business entities to take up function as commission agents for micro-insurance businesses.
- Absence of a specific institution mandated to oversee the agricultural insurance business.
- Lack of coordination that would hasten public-private partnerships in agricultural insurance.

3.4.10 Recommendations

- Inclusion of agricultural insurance as a viable disaster risk-financing strategy in the new economic reform agenda of the Ethiopian government.
- Increased awareness of regional governments (e.g. Oromia and Somali) about the benefits of IBLI.

4 Conclusions and Implications

There are several livestock innovations promoted by the government and different non-governmental organizations in Ethiopia. We focus on the most critical and crosscutting innovations that can address the major bottlenecks hindering development of the Ethiopian livestock sector and tackle youth unemployment, one of the most urgent macro-economic issues. Promotion of apicultural innovations requires relatively smaller financial investment, smaller amounts of land for forage development and easily attainable technical skills and knowledge. Given huge domestic and export demands for honey, beeswax and other bee products, it is possible to engage millions of young males and females in such a business that supports environmental sustainability while having a significant positive impact on agricultural productivity. Feed development innovations provide very attractive investment opportunities for private sector operators both in terms of production and marketing of feed and boosting livestock production in the country. In both cases, the country will benefit from job creation, better nutrition and food security, increased foreign earnings and economic growth.

With the largest livestock population in Africa and huge potential in the beef industry, promoting integrated beef operations along with feed innovations could have a significant impact on the competitiveness of the Ethiopian beef export sector. Given strong commitment to transform the sector, private sector operators can enter such a lucrative investment venture. Promotion of livestock insurance is a cross-cutting innovation that ensures the feasibility of the other three innovations mentioned in this document. IBLI is a scalable innovation that the government of Ethiopia and other IGAD member countries are trying to promote in the region.

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