Program for climate-smart livestock systems

Country stocktake: Ethiopia

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International Livestock Research Institute

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Contents

Summary

This is one of a series of documents that summarises information relating to the livestock sector in the three PCSL countries (Ethiopia, Kenya and Uganda). Prevailing livestock systems and their baseline performance in Ethiopia is summarised first, followed by a summary of what is known about the impacts of climate change on livestock production and livestock systems. Section 4 briefly summarises some recent research on adaptation and mitigation options for livestock systems in Ethiopia. Section 5 considers some of the work that has been done to date on projections for the livestock sector to the middle of the century. Section 6 considers the national livestock and climate change policy environment. The paper concludes with a consideration of system intervention points and major gaps in knowledge, to help guide project activities in Ethiopia.

1. Introduction and background

The livestock sector is a major contributor to food security in sub-Saharan Africa (SSA), contributing a vital source of income to many rural poor people as well as providing critical nutritional benefits through animal source foods that are protein dense and that contain a wide array of micronutrients. Agricultural production in general is highly vulnerable to climate change, and in the drylands, livestock systems mainly depend on scarce water and vegetation resources. In the future, more frequent and intense extreme events such as drought will exacerbate the challenges faced by livestock keepers in the region. Livestock production is not only affected by climate change but also contributes to it. In many countries in the region, the agricultural sector is the largest source of greenhouse gas (GHG) emissions, a large proportion of which comes from livestock production. Such emissions are released during the digestive process of ruminants, the storage and application of manure, and fodder production. Poor animal health and low-quality feeds leading to low productivity contribute to the GHG burden.

The Program for Climate-Smart Livestock systems (PCSL), funded and coordinated by the German Corporation for International Cooperation GmbH (GIZ) and implemented by the International Livestock Research Institute (ILRI) in partnership with the World Bank, was set up to support the identification and uptake of interventions to increase the contribution of livestock production to the three key pillars of climate smart agriculture (CSA): increased productivity, mitigation of GHG emissions, and adaptation to climate change (Lipper et al., 2014). The program, running from 2018 to 2022, is being implemented across major livestock productions systems in three focus countries: Kenya, Ethiopia and Uganda. The objective of the program is that key livestock stakeholders will increasingly direct their practices, sector strategies and policies and investments towards more climate-smart livestock systems. PCSL is supporting governments, the private sector, and local stakeholders in realizing their development objectives. The program is supporting countries to improve their monitoring and reporting of their Nationally Determined Contributions (NDCs) in the livestock sector, helping them to achieve their adaptation and mitigation goals.

This document focuses on Ethiopia. Section 2 summarises information on the prevailing livestock systems in the country, along with their baseline performance. The livestock systems in the two PCSL study regions are briefly characterised. Section 3 contains a stock take of what is known about the impacts of climate change on livestock production and livestock systems in the country. A summary of adaption and mitigation options in Ethiopian livestock systems is presented in section 4. Section 5 summarises some recent work on foresight and the future of livestock systems and the livestock sector in Ethiopia. Section 6 considers the national livestock policy environment, and in section 7, the paper concludes with a consideration of system intervention points and major gaps in knowledge, to help guide future project activities. This stocktake draws on a large amount of existing information assembled from different sources.

2. Livestock systems and their characterisation

Agriculture is the mainstay of Ethiopia's economy and the primary source of employment for its population. The agriculture sector contributed approximately 31 percent to the gross domestic product (GDP) in 2018 and employed two -thirds of the economically active population (World Bank, 2019). The livestock sector, one of the largest in the world in terms of number of animals, contributes 16–20 percent to the national GDP and represents a key subsistence source for some 10 million pastoralists. The great majority of export earnings come from agriculture, including coffee, livestock products (hides, skins), and seeds and pulses. Cereal production is mostly for subsistence.

Ethiopia has had very rapid economic growth, exceeding 10 percent annually over the last decade. The rural population is still large, at nearly 80 percent of the total population. An estimated 21 million of the country's (then 90 million) population in 2011 were classified as livestock keepers living under the national poverty line (Table 1d). Human population now stands at about 109 million (FAOSTAT, 2019), about 8.5 percent of the continent's total. Livestock contributes about 35 percent to agricultural GDP. Ruminant animals are a very important component of the livestock sector in Ethiopia. For the year 2017, FAOSTAT estimates that there were around 61 million cattle, 59 million chickens, and more than 63 million sheep and goats (collectively) in Ethiopia (FAOSTAT, 2019). These represented 18 percent of the total cattle population and 13 percent of the sheep and goat population of Africa in 2017. Such statistics highlight very clearly how important livestock sector interventions in Ethiopia could be to the region in general. Interventions that affect Ethiopia's ruminant meat or milk sector, and/or its human population, invariably affect a sizeable proportion of the continent.

Agriculture occupies around 35 percent of the total land area of 1.1 million km^2. There are approximately 17.5 million agricultural land holders in the country, occupying 18 million ha of land. Women represent only 19 percent of total agricultural land holders. Most farm holders are smallholders, with farm sizes of less than two ha, and they produce over 90 percent of gross agricultural output. Larger commercial farms (over 10 ha) are not widespread; extending over 1.2 percent of the total agricultural land area, they contribute less than 5 percent of gross agricultural output. There has been a steady increase in area under grain crops (cereals, pulses, oilseeds) over the past decades, from 10 million ha in 2005/2006, to 12.4 million ha in 2014/2015. Agricultural expansion has had substantial effects on the availability and quality of natural resources, particularly forests, water and soils (CIAT, 2017).

Table 1a-d. Selected statistics for Ethiopia and livestock

Table 1a. Selected macro-indicators

Total human population (million)	Rural population (% total)	Poor livestock keepers (% rural population)	Annual GDP per capita (constant 2010 USD)	GDP growth (% annual, avg. 2008-2017)	Population growth (% annual, avg. 2008-2017)
104.9	79.7	28.4	549.85	10.1	2.6

Sources: Estimates are for 2017 and come from the World Bank Indicators (World Bank, 2019). Estimates of the % of rural people and of percent who keep livestock and live below nationally defined poverty lines are from Robinson et al. (2011).

Table 1b. Contribution of livestock to national income (GDP) and stocks of live animals

Contribution of livestock sector to agricultural GDP (%)	Agricultural GDP to national GDP (%)	Contribution of livestock sector to GDP (%)	Livestock population (millions)				
			Cattle	Sheep	Goats	Pigs	Poultry birds
35.6	42.7	15.2	56.7	29.3	29.1	0.034	56.8

Source: 2014 data retrieved from FAOSATAT (2019).

Table 1c. Selected measures of livestock production, food availability and nutrition

Meat production ('000 MTs)	Dairy & egg production ('000 MTs)	Per capita supply of LDF (Kg / person / year)	LDF % of food supply (Kcal / person / day)	LDF % of protein supply (g / person / day)	Prevalence of underweight children <5 (%)
694.00	4,037.33	49.92	5.93	12.52	29.20

Sources: data on prevalence of underweight is a 3-year average using World Bank estimates for 2011-13 (World Bank, 2019). The data on the other indicators are 3-year averages of published national statistics (FAOSTAT, 2019).

Table 1d. Number of 'poor livestock keepers' by system

Pastoral	Mixed crop-livestock	Other	All systems
1,772,000	18,979,000	256,000	21,007,000

Source: Robinson et al., 2011, using the World Bank nationally-defined poverty lines

Cattle production is one of the main agricultural industries in Ethiopia. The country produces over 3.8 billion litres of milk and about 1 million tonnes of beef per year valued at USD 2.5 billion and USD 5.1 billion, respectively (ASL, 2018). Cattle are spread throughout the country in a variety of different production systems. Figure 1 shows the distribution of livestock systems using the classification system of Seré and Steinfeld (1996). Grassland-based systems are those in which more than 90 percent of dry matter fed to animals comes from rangelands, pastures, annual forages and purchased feeds and less than 10 percent of the total value of production comes from non-livestock farming activities. The mixed systems are those in which more than 10 percent of the dry matter fed to animals comes from crop by-products or stubble, or more than 10 percent of the total value of production comes from non-livestock farming activities (Seré and Steinfeld, 1996). The mixed systems are further split into those that are rainfed and those that are irrigated. These three major system types (mixed crop-livestock rainfed, mixed crop-livestock irrigated, and pastoral / agropastoral) are then broken down on the basis of temperature and length of growing period (Robinson et al., 2011).

In Ethiopia, the great majority of cattle keepers are in the mixed crop-livestock (almost all rainfed) and pastoral / agro-pastoral systems. Two other production systems are of importance in the country: market oriented intensive specialized (diary and commercial feedlots) and urban/peri-urban production systems (Table 2, Table 3). Note that these are not mapped in Figure 2 as part of the classification system used. Generally, there is limited supply of animal products in relation to the total population, with consumption of animal products lowest among the rural populace. Milk is however a major component of the diet in pastoral areas.

Two contrasting study regions were identified for PCSL project activities: one in Afar region, and one in Amhara region. Some household characteristics of these areas using existing survey data are shown in Box 1 and Box 2.

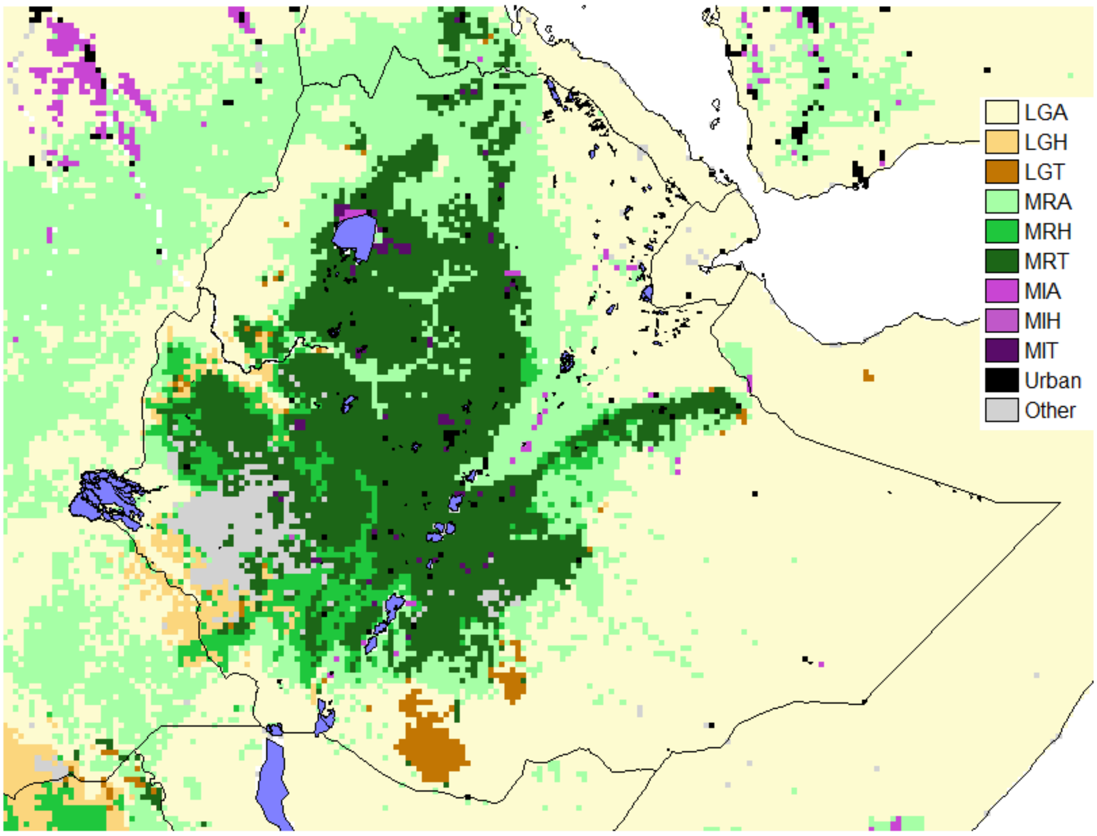


Figure 1. Livestock systems of Ethiopia, according to the classification of Sere and Steinfeld (1996) mapped in Robinson et al., (2011).

LG, pastoral / agro-pastoral systems (in which >90 percent of dry matter fed to animals comes from rangelands, pastures, annual forages and purchased feeds and <10 percent of the total value of production comes from non-livestock farming activities.

M, mixed crop-livestock systems (MR, rainfed; MI, irrigated) in which >10 percent of the dry matter fed to animals comes from crop by-products or stubble, or >10 percent of the total value of production comes from non-livestock farming activities.

A, arid / semi-arid; H, humid / subhumid; T, tropical highland.

Table 2. Short description of cattle production systems in Ethiopia (ASL, 2018).

Production system	Short description
Mixed crop-livestock (dairy and beef)	Subsistence oriented farming concentrated in the cool tropics sub-humid / humid agroecological zones where cereals and cash crops are the dominant farm activities. Cattle supply draft power and milk.
Pastoral/Agropastoral (dairy and beef)	Rangeland based livestock production system aimed at exploitation of the natural or seminatural vegetation via domestic animals, in particular ruminants. The main product is milk and the main function of livestock is subsistence, although social and cultural functions are also important. Excess young males are sold to highlanders, where they are used as draught oxen, or to feedlot operators.
Urban/Peri-urban (dairy and beef)	Urban/Peri-urban dairy is an expanding production system largely found in the cool tropics (highlands) and concentrated in the Addis Ababa milk shed area as well as around the regional capital cities where there is an adequate market for fresh milk. Smallholder farmers and landless households around urban areas fatten a few animals at a time. Fattening is mostly done after the oxen in the mixed crop-livestock system have retired from farm work in order to replace them with younger animals.
Dairy commercial	Specialized commercial dairy systems involving higher levels of investment are concentrated in the central highland plateau. In terms of scale of operation, the farms are classified as large-, small- or medium-scale. Being licensed farms with operational business plans, they are market oriented specifically targeting consumers in urban areas. The animals do not provide draft power but their manure is used as fertilizer.
Commercial feedlots	There are >300 feedlots operating in Ethiopia, predominantly in East Shoa (Oromia). Animals are entirely confined in a yard with watering and feeding facilities for a finishing duration of 3-6 months.

Table 3. Number of holdings and people keeping cattle (ASL, 2018).

Production system	No of cattle-keeping households	Number of people living in cattle-keeping households	Average household size
Mixed crop-livestock	10,583,073	57,715,530	5.5
Pastoral/Agro-pastoral	948,544	5,852,244	8.3
Urban/Peri-urban	612,644	3,439,022	5.6
Dairy commercial	425,733	2,283,074	5.4
Total	***12,569,994***	***69,389,870***	

Box 1. Data summary sheet for the Afar region, Ethiopia

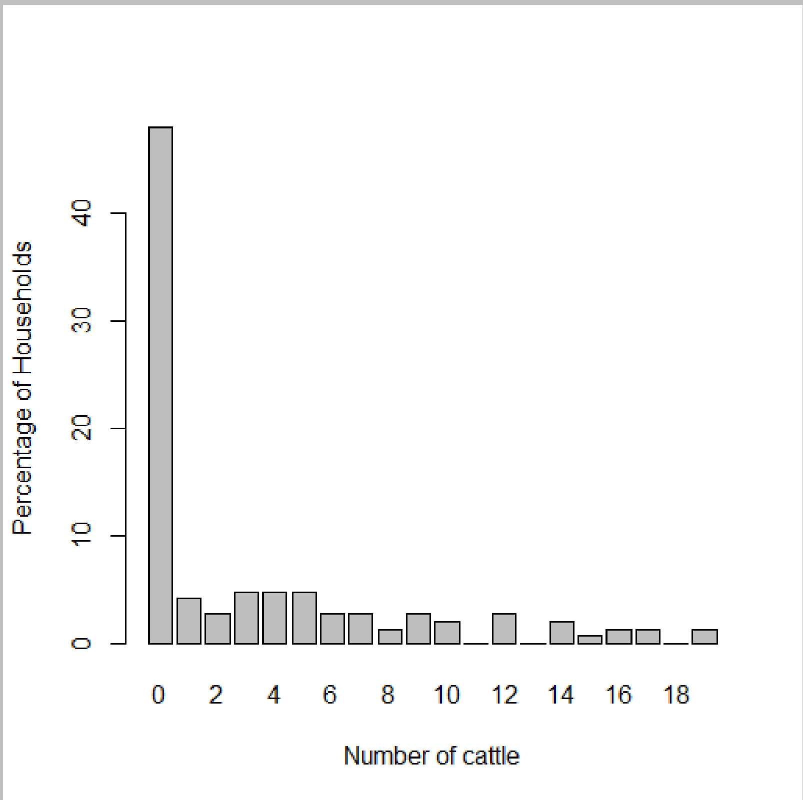
A. Location of 144 households, data used from the World Bank's LSMS ISA survey, 2011 – 2012

B. Key information

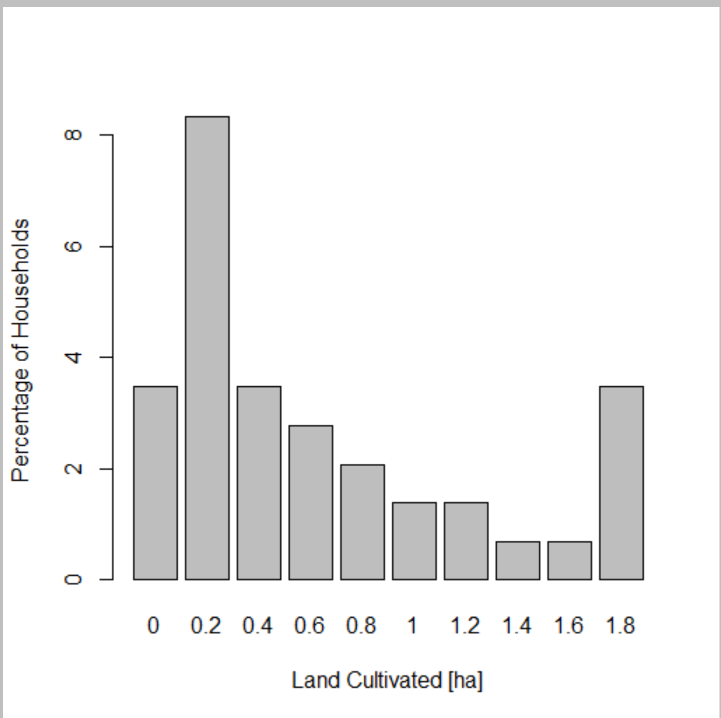
Variable	Value
Average farm size [ha] (standard deviation)	1.2 (1.0)
Average livestock holding [tropical livestock units]	11 (14)
Average number of cattle	13 (17)
Average number of chicken	0.04 (0.5)
Average number of goats	15 (20)
Average number of sheep	9 (16)
Total farm income generated [USD PPP corrected per household per yr]	-
Total livestock income generated [USD PPP corrected per household per yr]	118
Total value of livestock prod consumed [USD PPP corrected per household per yr]	18
Average milk production per cow (l/producing animal/day)	1.4 (0.9)
Milk production per cow of 10% best producing farms (l/producing animal/day)	2.4 (0.3)
Average egg production per chicken [d^{-1}]	0.35 (0.2)
Egg production per chicken of 10% best producing farms	0.6 (0.1)

Source: World Bank Living Standard Measurement Survey – Integrated Survey on Agriculture. Crop information in these data are missing.

C. Distribution of cattle holdings per household



D. Distribution of cultivated land size per household



Box 2. Data summary sheet for the Debre Birhan region, Ethiopia

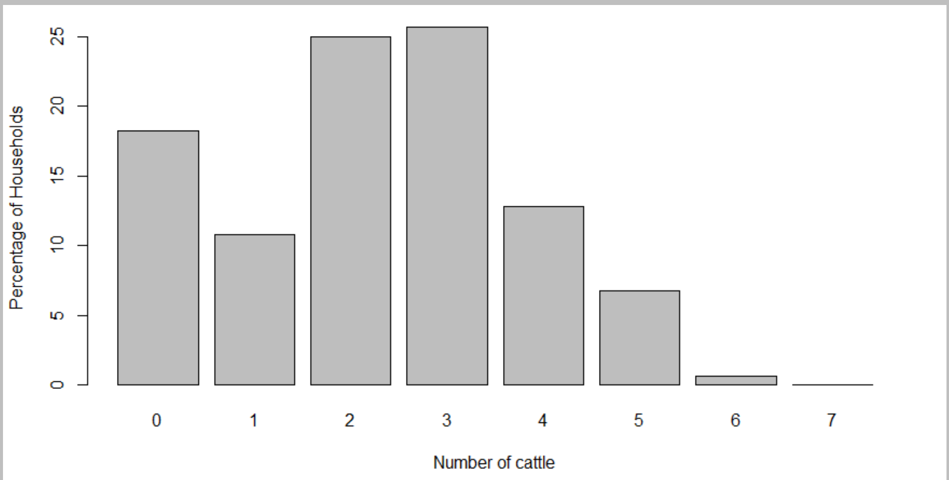
A. Location of 148 households surveyed

B. Key information

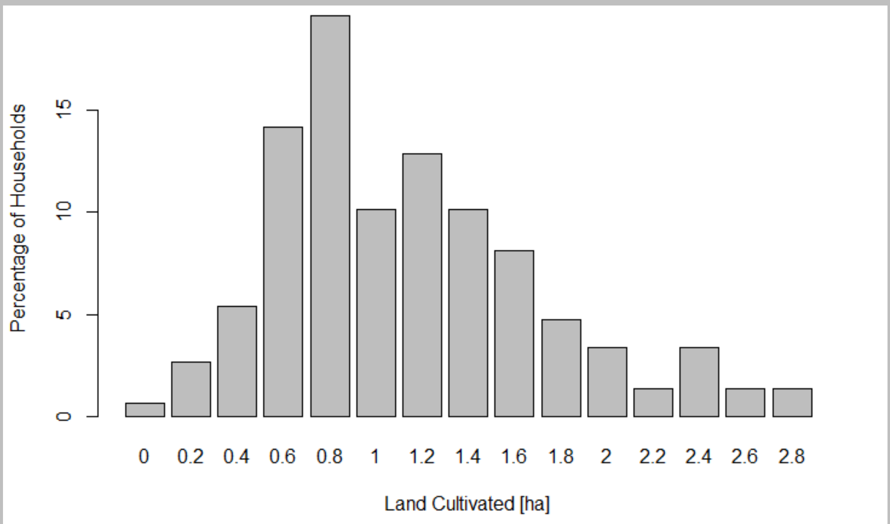
Variable	**Value**
Average farm size [ha] (stdev)	1.3 (0.6)
Average livestock holding [tlu]	4.0 (2.0)
Average number of cattle	3.2 (1.7)
Average number of chicken	4.6 (3.7)
Average number of sheep	7.3 (5.1)
Total farm income generated [USD PPP corrected per household per yr]	903 (3500)
Total livestock income generated [USD PPP corrected per household per yr]	488 (1273)
Total value of livestock prod consumed [USD PPP corrected per household per yr]	120 (344)
Average milk production per cow (l/producing animal/day)	3.3 (3.5)
Milk production per cow of 10% best producing farms (l/producing animal/day)	12.2 (4.8)
Average egg production per chicken	-
Egg production per chicken of 10% best producing farms	-

Source: RHoMIS (Rural Household Multiple Indicator Survey; www.rhomis.org) application in Ethiopia in 2018 as part of an AfricaRISING baseline study in 4 different regions; 148 household were surveyed in Debre Birhan.

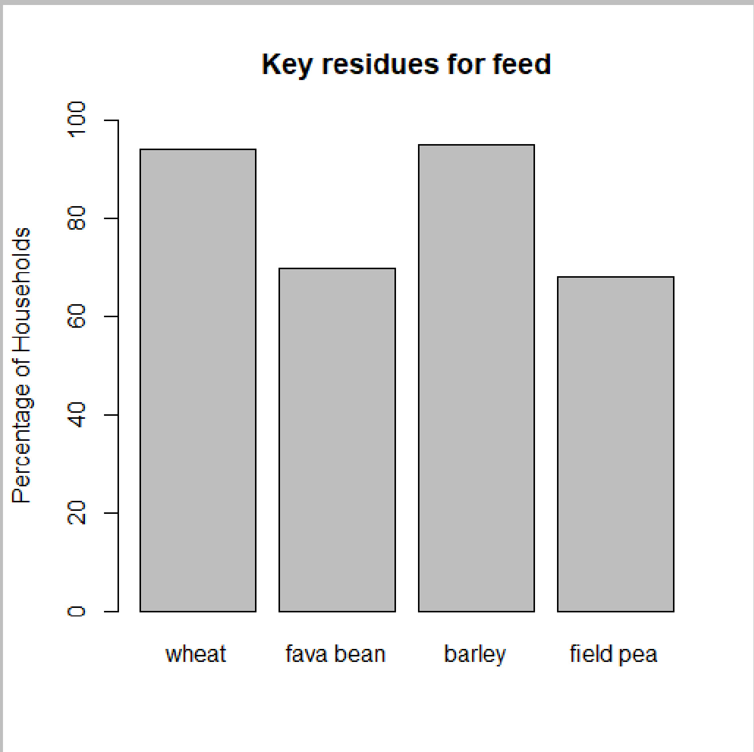
C. Distribution of cattle holdings per household



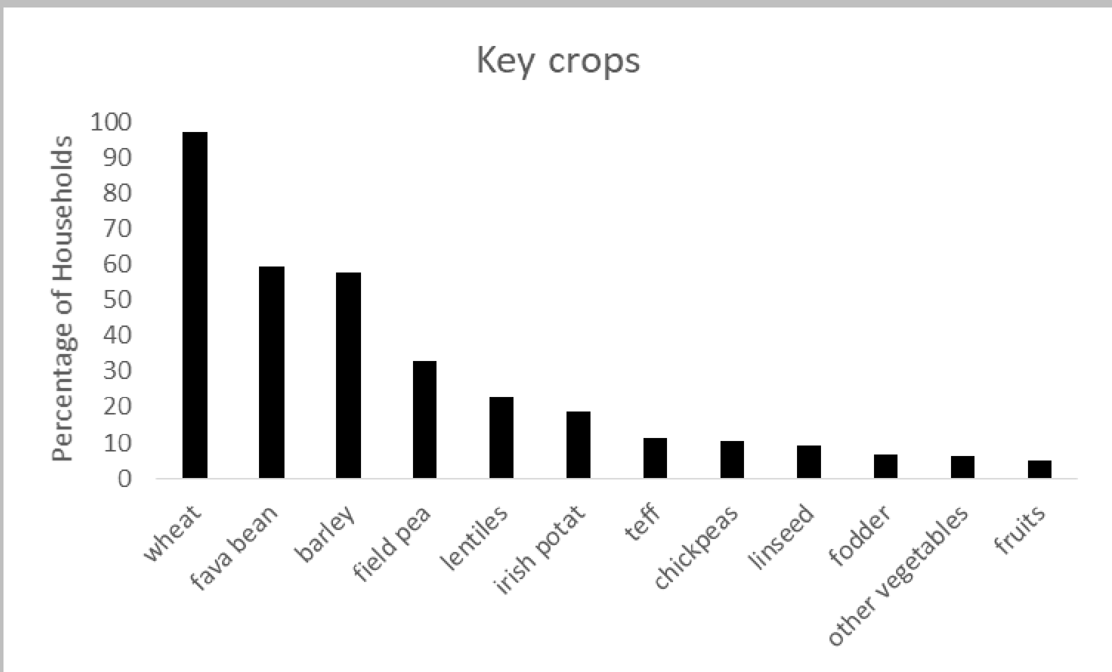
D. Distribution of cultivated land size per household



E. Major crop residues fed by households



F. Major crops grown by households



3. Impacts of climate change on livestock systems and livestock production

Temperature and rainfall vary considerably across Ethiopia. There is a trend of decreasing temperatures and increasing rainfall from the lowlands in the south- and north-east to the central and upper highlands, with rainfall >2000 mm annually in the southwestern highlands compared with 300 mm in the lowlands. Seasonal regimes differ too: a wet season from June to September is common throughout much of the country, with rainfall reaching as high as 350 mm per month, though farmers and pastoralists in the north and centre rely on an additional short wet season from February to May. Southern parts are exposed to rains during February–May and October–December, though rain is scarce in the far eastern parts of the country (MOFAN, 2018). Since the 1980s, Ethiopia has suffered more frequent droughts, increases in mean temperatures, more erratic rainfall, and more frequent heavy rains (CIAT, 2017). These changes have had an impact on farmer livelihoods as well as on national economic performance: in Ethiopia, there has historically been a close relationship between annual rainfall variability and agricultural GDP as well as affecting overall GDP growth. Droughts especially continue to have great impact on farmers' livelihoods, leading to crop damage, loss of animals and livelihoods, migration to urban areas and increases in malnutrition.

For the future, projections indicate a continued increase in mean temperature throughout the entire country, with the greatest increases expected to be experienced in the northern parts of the country. Higher variability of rainfall is also expected, with rains becoming more unpredictable, more unreliable, and more intense. Climate projections indicate increases in annual rainfall for Ethiopia as a whole, with increases being greatest in the southern and south-eastern parts of the country and least in the central and northern parts of the country. These increases are largely a result of increasing rainfall during the short rainfall season (October–December) in southern Ethiopia. Overall, future changes in rainfall are highly variable, with some combinations of climate model and GHG emission scenario suggesting decreases in places (CIAT, 2017).

The impacts on agricultural systems may be considerable. Temperature shifts are likely to change the distribution and productivity of major staples (decreasing suitability for beans and maize, for instance) (CIAT, 2017). For livestock systems in Ethiopia, projections indicate some increases in net primary productivity in the highlands, and some reductions in the drier areas, though less extensive reductions than in the Sahel and parts of southern Africa, for example (Boone et al., 2018). Other projections indicate widespread negative impacts on forage quality and thus on livestock productivity, with cascading impacts on incomes and food security (Thornton et al., 2015; Thornton et al., 2018). In addition to climate change effects on the quantity and quality of feeds, other effects are anticipated on water availability in livestock systems, and on the distribution and severity of livestock diseases and their vectors (see, for example, reviews in Rojas-Downing et al., 2017; Mbow and Rosenzweig, 2019).

Other, more indirect effects of climate change on agriculture and food systems are gaining in importance. Recently, Smith and Myers (2018) projected that the effects of elevated CO_2 concentrations by the 2050s on the sufficiency of dietary intake of iron, zinc and protein an additional 175 million people will be zinc deficient and an additional 122 million people will be protein deficient. The mechanism is via more carbohydrates being produced in C3 crops at the expense of other nutrients such as protein, iron and zinc. Similar effects on forage quality have been found in forages (Augustine et al., 2018). About 57 percent of grasses globally are C3 plants (Osborne et al., 2014) and thus susceptible to CO_2 effects on their nutritional quality. These impacts will result in greater nutritional stress in grazing animals as well as reduced meat and milk production. Another impact of climate change is that of higher temperatures on the capacity of people to work in the fields (Watts et al., 2017) and on the ability of livestock to cope with heat stress. Both may have major implications for livelihoods based on livestock keeping; for Ethiopia, preliminary analyses indicate that heat stress in cattle may become a widespread and serious problem as the century progresses (Thornton et al., 2020).

While there is growing evidence that the risk of extreme events will increase in the future, the ways in which these risks will manifest themselves and affect agricultural systems are not always that clear (Thornton et al., 2014). Increasing climate variability and extremes have been identified as one of the key drivers behind the recent rise in global hunger and a leading cause of severe food crises (FAO, 2018), affecting both crop and livestock systems. Forage production and animal stocking rates can be significantly affected by drought intensities and durations as well as by long-term climate trends. After a drought event, herd size recovery times in semi-arid rangelands may span years to decades in the absence of proactive restocking through animal purchases, for example (Godde et al., 2019). Indeed, increasing climate variability may threaten the long-term viability of agriculture-based livelihoods in many places.

A summary of climate hazards in Ethiopia is shown in Figure 2 (from Thornton et al., 2019). The areas of vulnerability were projected for the 2050s based on RCP 8.5, a high GHG emission scenario, using the methods in Jones and Thornton (2013; 2015), overlaid on cropland and pastureland from the data set of Ramankutty et al. (2008). In these areas of cropland, pastureland or mixed land-use, hazards were mapped with respect to three main hazards:

- Areas where the coefficient of variation of annual rainfall (the standard deviation divided by the mean, expressed as a percentage) is currently greater than the median value for the global tropics (24 percent). In lower latitudes, climate change is projected to increase this variability, making both cropping and rangeland production more risky. Because there is little information on the nature of this variability change, current variability is used as a proxy for future variability.

- A reduction in the number of reliable crop growing days per year below 90, a critical threshold for rainfed cropping (Nachtergaele et al.,2002), mostly due to changes in rainfall distributions and amounts.
- Increases in average maximum temperature during the primary growing season above 30 $_{0}$C), a critical threshold for several major crops (Boote et al., 1998; Prasad et al., 2008).

Areas where more than one of these hazards is projected to be present are also shown in Figure 2.

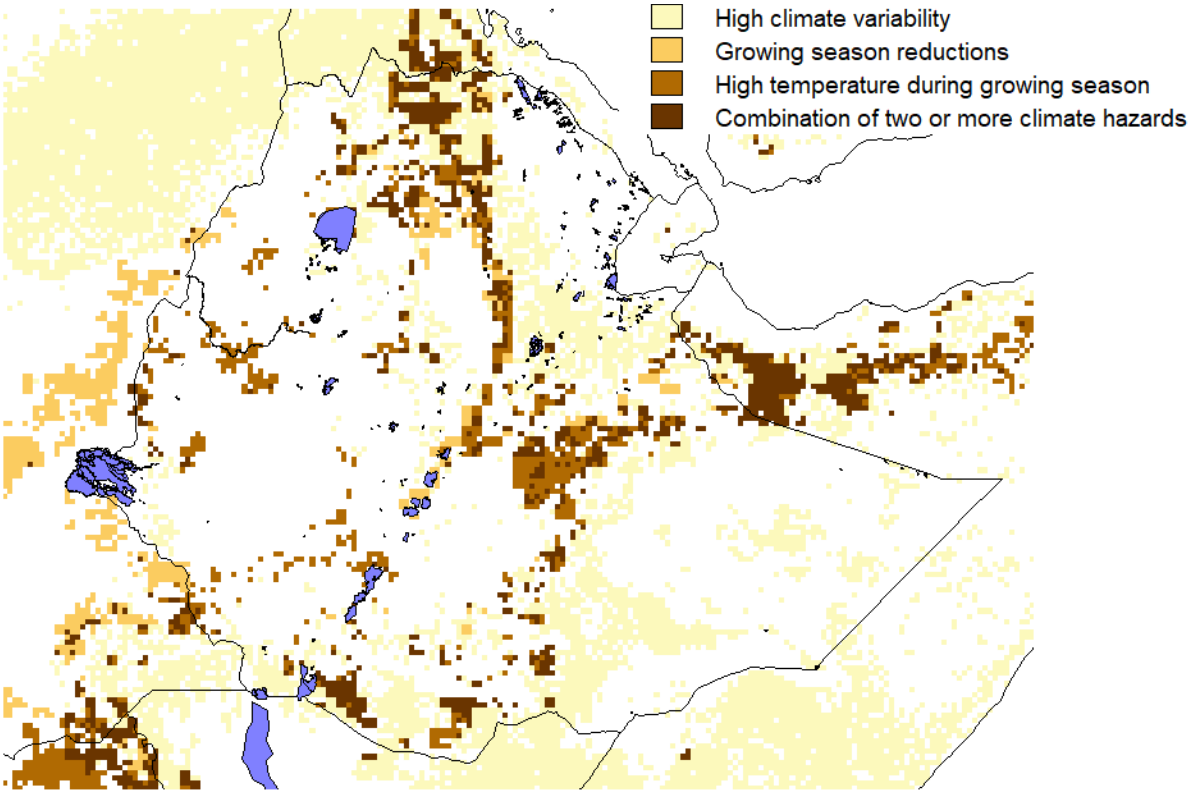


Figure 2. Areas of high agricultural risk for different climate hazards in vulnerable areas of Ethiopia (from Thornton et al., 2019).

Areas of vulnerability are projected for the 2050s based on RCP 8.5 overlaid on cropland and pastureland (Ramankutty et al. 2008) with respect to: (1) areas where the coefficient of variation of annual rainfall is currently greater than the median value for the global tropics; (2) reduction in the number of reliable crop growing days per year below 90 mostly due to changes in rainfall distributions and amounts; (3) increases in average maximum temperature during the primary growing season above 30°C. Methods as in Jones and Thornton (2013; 2015) using an ensemble mean of 17 climate models from the Coupled-Model Inter-comparison Project 5 (CMIP5) of the IPCC.

Two other important climate hazards are the frequency and severity of drought and of flood. Figure 3 shows relative drought risk and flood hazard distribution maps for the East African region, from Dilley et al. (2005), CHRR/CIESIN (2005), and CHRR/CIESIN/IRI (2005). Table 4 lists the PCSL intervention districts (woredas) in Afar and Amhara with respect to agro-ecological zone, livestock system and climate hazard (Figures 2 and 3). Their locations are shown in Figures 4 and 5.

Table 4. PCSL intervention districts (woredas) sites in Ethiopia.

Site	Region	Woreda	Predominant Agro-Ecological Zone(s)	Livestock systems	Climate hazard(s)
1	Afar	Awura	Lowland – Semi-arid	Pastoral (LGA), Mixed / agro-pastoral (MRA)	High climate variability Medium-high drought and flood risk
2	Afar	Ewa	Lowland – Semi-arid	Pastoral (LGA), Mixed / agro-pastoral (MRA)	High climate variability Medium-high drought and flood risk
3	Afar	Chefera	Lowland – Semi-arid	Pastoral (LGA), Mixed / agro-pastoral (MRA)	High climate variability Medium-high drought and flood risk
4	Amhara	Basona Worana	Upper Highland – Semi-humid, Lower Highland – Semi-humid to semi-arid	Mixed / agro-pastoral (MRT)	High climate variability Medium-high drought and flood risk
5	Amhara	Tarma Ber	Upper Highland – Semi-humid, Lower Highland – Semi-humid to semi-arid	Mixed / agro-pastoral (MRT, MRH)	Multiple climate hazards Medium-high drought and flood risk

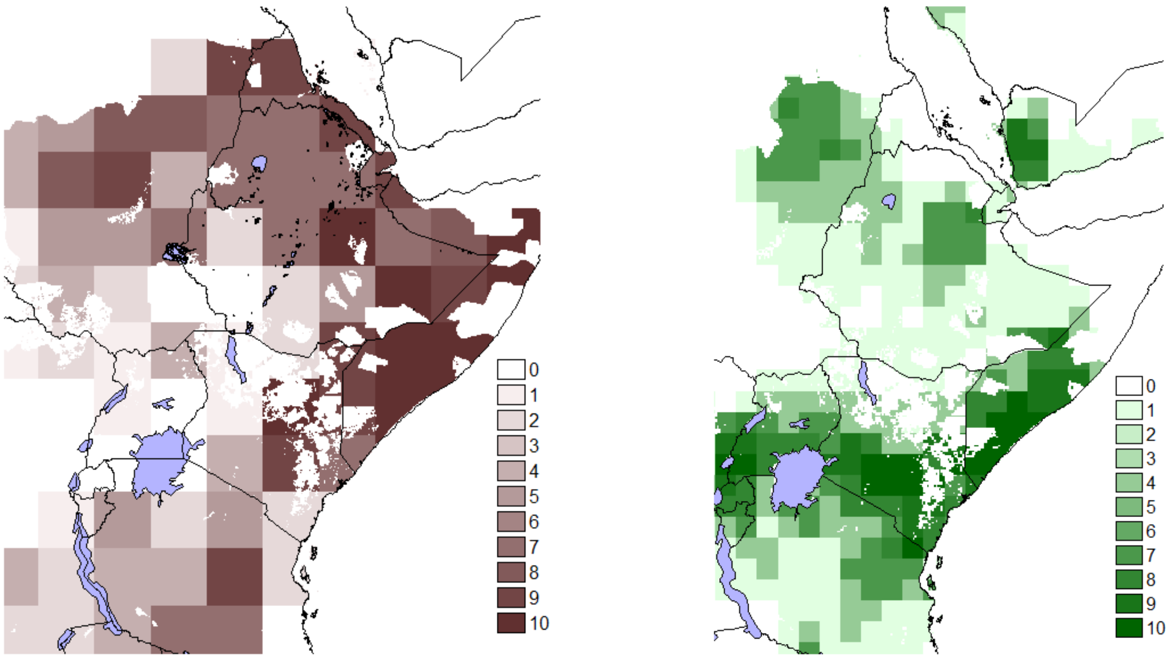


Figure 3. **Top**: drought risk, 1989-2000, deciles (1 low, 10 high). Source: Dilley et al. (2005), CHRR/CIESIN/IRI (2005

Bottom: flood hazard frequency and distribution, 1985-2003, deciles (1 low, 10 high). Source: Dilley et al. (2005), CHRR / CIESIN (2005).

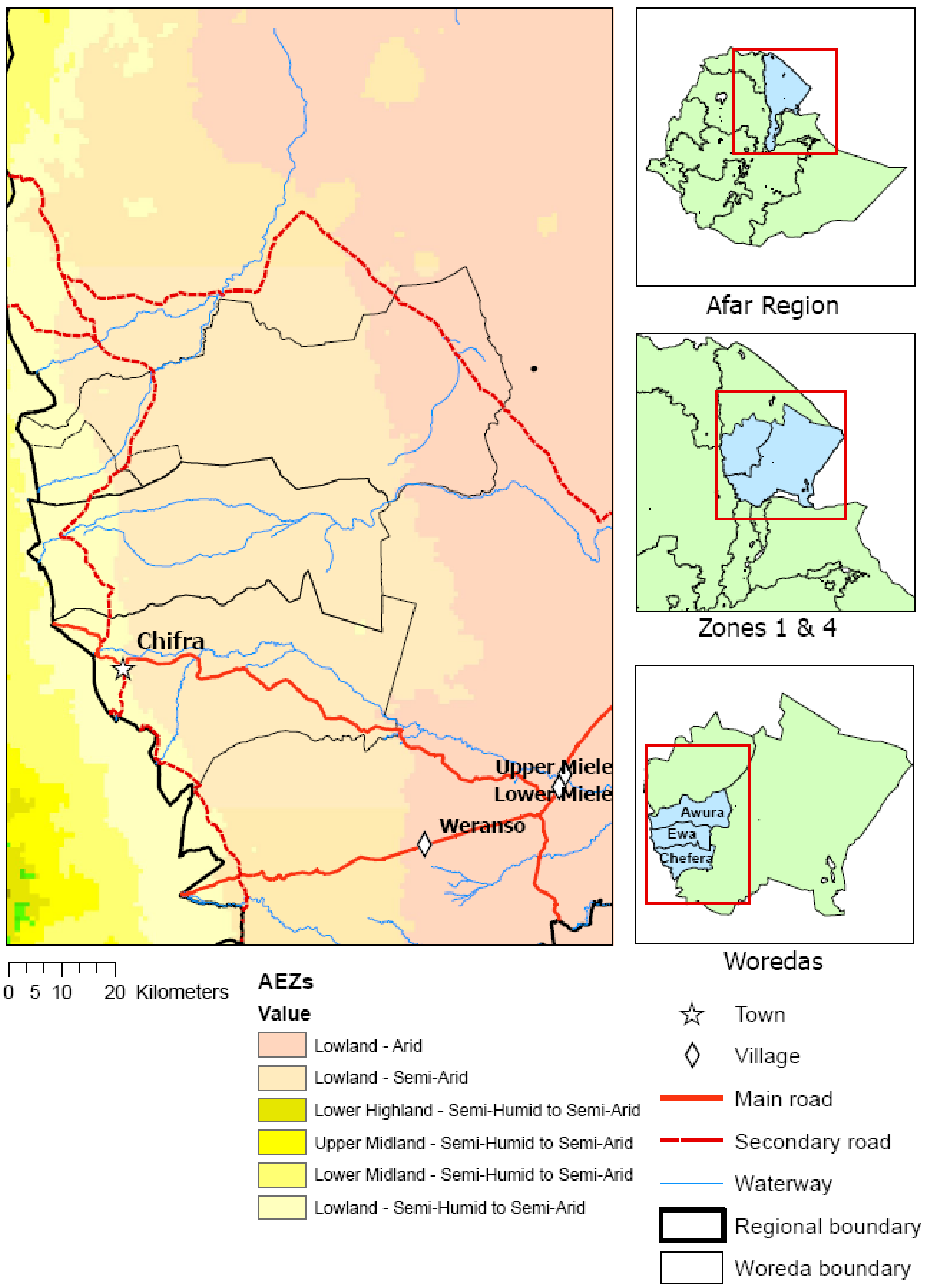


Figure 4. PCSL intervention woredas in Afar, Ethiopia

Lower Highland: mean temp 15-18 °C, 1829-2438 m altitude. Upper Midland: mean temp 18-21 °C, 1219-1829 m altitude. Lower Midland: mean temp 21-24 °C, 914-1219 m altitude. Lowland: mean temp >24 °C, <914 m altitude.

Arid: 1-3 wet months per year, 200-400 mm annual rainfall. Semi-arid: 3-4 wet months per year, 300-600 mm annual rainfall. Semi-humid to semi-arid: 4-6 wet months per year, 500-1000 mm annual rainfall.

Agro-ecological zones modified from Karanja (2006).

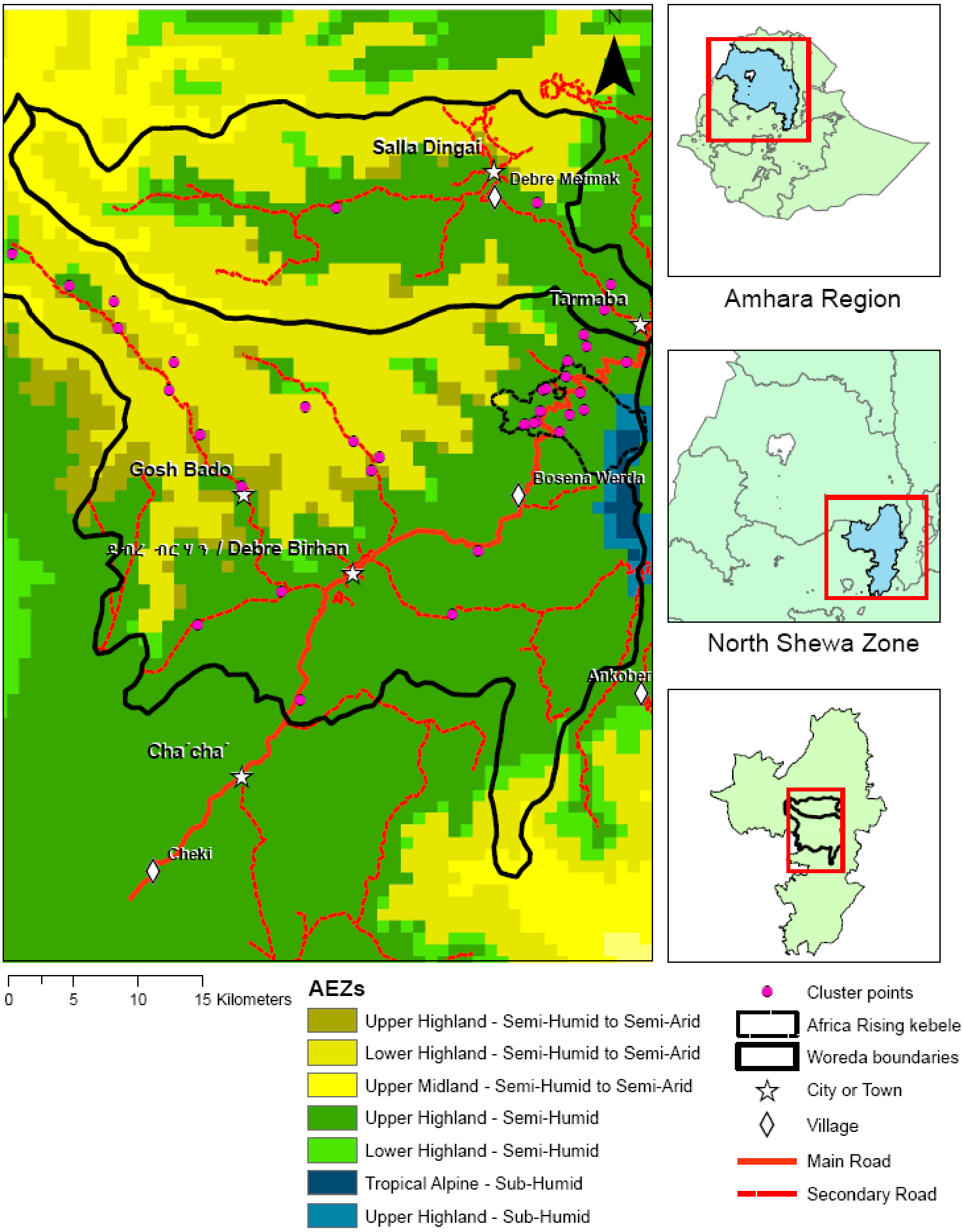


Figure 5. PCSL intervention woredas in Amhara, Ethiopia

Upper Highland: mean temp 10-15 °C, 2438-3048 m altitude. Lower Highland: mean temp 15-18 °C, 1829-2438 m altitude. Upper Midland: mean temp 18-21 °C, 1219-1829 m altitude. Tropical Alpine: mean temp 2-10 °C, >3048 m altitude.

Sub-humid: 9-12 wet months per year, 1200-1500 mm annual rainfall. Semi-humid: 6-9 wet months per year, 950-1200 mm annual rainfall. Semi-humid to semi-arid: 4-6 wet months per year, 500-1000 mm annual rainfall.

Agro-ecological zones modified from Karanja (2006).

4. Adaptation and mitigation options

From a technical viewpoint, there is a wide range of interventions in livestock systems that can help livestock keepers adapt and become more resilient to climate change; many of these have mitigation co-benefits too. Table 5 from Bell et al. (2018) lists some of these practices, scored for their potential to address climate risks including those shown in Figure 3.

Table 5. Interventions in livestock systems and their potential to address different climate hazards. From Bell et al. (2018).

Livestock	Addressing Climate Risks				
Practices	Increased growing season temperature	Intra-seasonal droughts	Shortening of growing seasons	Unpredictable seasons	Increased rainfall intensity
	Diet Management				
Non-conventional feeds	+	+	+	+	+/-
Improved feed quality	+/-	+	+/-	+/-	+/-
Improved digestibility	+/-	+	+/-	+/-	+/-
Improved protein content	+/-	+	+/-	+/-	+/-
Improved supplements	+	+	+/-	+	+/-
	Improved Pastures				
Planting N-fixing legumes	+/-	+/-	+/-	+	+
Fodder shrubs	+/-	+	+/-	+	+
	Rangeland Management				
Rotational grazing	+/-	+	+/-	+	+
Cut-and-carry	+/-	+	+	+	+/-
	Manure Management				
Manure collection	+/-	+/-	+/-	+/-	+/-
Improved manure storage	+	+/-	+/-	+/-	+/-
Manure treatment	+	+/-	+/-	+/-	+/-
Vaccines	+	+	+/-	+/-	+/-
Changing breeds	+	+	+/-	+	+/-
Artificial insemination	+	+/-	+/-	+/-	+/-
Wells (boreholes)	+	++	+/-	+	+/-

Direction (+, -) relates to whether a practice has a positive (ameliorating) or negative (exacerbating) impact on the climate risk. Magnitude is shown by the intensity of the color in the gradient and the number of symbols, where more symbols is a larger impact. Boxes with a +/- sign indicate practices that either (1) do not address the climate risk, (2) there is not enough known to make a recommendation, or (3) the effect may be highly context specific.

Figure 6 shows two CSA practices with reasonable climate smartness scores according to expert evaluations, from a more extensive list developed for Ethiopia: feeds and feeding systems improvement, and veterinary services improvement. The average climate smartness score is calculated based on the individual scores of each practice on eight climate smartness dimensions that relate to the CSA pillars: yield (productivity); income, water, soil, risks, information (adaptation); energy, carbon and nutrients (mitigation). A practice may have a negative, positive or zero impact on a selected CSA indicator, with 10 (+/-) indicating a 100 percent change (positive or negative) and 0 indicating no change. These two interventions have been identified as among the major priorities for the livestock sector in Ethiopia, particularly in view of likely future demand for livestock products, the need to reduce constraints to the expansion of feed production and processing, and the need for higher-quality animals (USAID, 2015).

Figure 6. “Smartness” assessment for some ongoing CSA practices by production system as implemented in Ethiopia. From CIAT (2017).

There is considerable scope in Ethiopian livestock systems for substantial improvements in both productivity and GHG emission intensities. Using household data from several sites, Herrero et al. (2016) identified yield gaps in dairy production in Ethiopia (the difference between what is typically achieved and what is possible) of between 65 percent and 350 percent, depending on the type of intervention package considered. Ethiopian dairy production may grow by 80 percent or more to 2030 (see section 5), and such production increases are achievable with interventions such as better feeding and wider use of crossbred animals (Herrero et al., 2016). Overcoming biomass constraints will be key to achieving such productivity increases. Cross-breeding dairy animals can substantially raise milk productivity, with the prospect of achieving production targets with fewer animals; but this will only work if higher quality feed is available (Herrero et al., 2016; Mayberry et al., 2017).

In Ethiopian dairy systems, forage grasses are the primary and secondary feed sources during both the wet and dry seasons. Climate change will have impacts on the suitability of different forage grasses in the future. Kekae et al. (2019) shows that in Ethiopia, Buffel grass is likely to be negatively affected by climate change in some regions of the country, while Rhodes grass and Napier grass are likely to have improved suitability under future climates. Such forage grasses in the future could contribute substantially to national feed demands, although adoption of improved forages is currently low. The impacts of climate change on forage species' nutritional density (and hence changes in their value as livestock feed) are still not known with any certainty.

For small ruminants, there is likewise significant potential for increasing production via practices to reduce mortality and strategic sowing of improved fodders. For goats, cross-breeding in these systems may be relatively ineffective, although a package with cross breeding allied with reduced mortality and improved feed could potentially double small ruminant meat production to 2030 compared with 2010. Reproduction, liveweight gain and survival rates can be increased through better nutrition, genetics and healthcare, but the biggest increase in production and profits occurred when multiple interventions were combined. Importantly, interventions resulting in the biggest increases in goat meat production or number of animals sold did not always give the highest profits (Mayberry et al., 2018).

The smallholder poultry sector in Ethiopia could potential supply a significant amount of meat and eggs, especially if improved interventions are applied. In Ethiopia, Herrero et al. (2016) found that the mean annual egg offtake for a small sized farm could be doubled using vaccination and supplementary feeding, and doubled too through the use of crossbreeding with more productive animals and providing daytime housing. The costs of providing supplementary feed can be highly variable, and the cost associated with providing daytime housing has large effects on profitability at the farm level (Herrero et al., 2016).

Many of the interventions noted above have important mitigation as well as adaptation benefits. Increasing Ethiopian milk production from 250 to 900 kg per cow can result in a reduction in emissions intensity from 45 kg CO_2 eq per kg of fat-and-protein corrected milk (FPCM) to 12 kg CO_2 eq per kg FPCM, i.e. a 73 percent decrease in emission intensity compared to baseline (FAO, 2017). In the FAO (2017) study, a range of interventions was assessed for production and financial benefits as well as methane mitigation benefits. The interventions were ranked by production systems with respect to reduction potential, increased production and high economic return. In Ethiopia's mixed crop-livestock systems, the use of improved breeds, urea feed-based interventions and disease control had moderate to high impact; moderate impact on emission reduction and returns on investment and a high impact on productivity. In the pastoral / agro-pastoral systems, the two interventions evaluated were supplementation with leguminous shrubs and trypanosomosis control; in more extensive systems, the control of trypanosomosis is an effective intervention in reducing enteric methane emission intensity, while having a positive impact on production and returns to farmers (FAO, 2017).

There are many barriers to the widespread uptake of interventions in Ethiopia that can help small-scale farmers to adapt to climate change, mitigate GHG emissions, and enhance their resilience. Jirata et al. (2016) highlight the following: the lack of adequate mechanisms for generating, capturing, and disseminating knowledge and information, both scientific and indigenous; the lack of a comprehensive capacity-development approach for all stakeholders that builds on a sound assessment of needs is required, such that appropriate interventions can be integrated into the country's extension system, so that technologies can effectively reach the wider community; and the lack of evidence-based promotion and upscaling of appropriate technologies, that could be attained through learning platforms for influencing policy-makers and for developing networks for the promotion of best practices. Increased public and private support to enable access to improved inputs, equipment, credit and insurance schemes is also needed to boost farmers' ability to manage risks and invest in long-term climate actions (CIAT, 2017). The national-to-local policy environment is a key enabler of uptake; this is considered in section 6 below.

5. Livestock systems in the future

Several studies have investigated the possible futures associated with livestock systems in countries of sub-Saharan Africa (e.g., Herrero et al., 2014; FAO, 2019). Enahoro et al. (2019) extracted a set of global projections for Ethiopia, and this section draws on and summarises that work.

Projections of demand and supply of livestock-derived food in 2030 and 2050 were developed by Enahoro et al. (2019) for several countries including Ethiopia using the IMPACT model, an integrated modelling system that links information from climate models, crop simulation models and water models to a core global, partial equilibrium, multimarket model focused on the agriculture sector (Robinson et al., 2015). IMPACT's multi-market model simulates the operations of global and national markets for more than 60 agricultural commodities, covering the bulk of food and cash crops traded globally. It solves for production, demand and prices that equate global supply and demand of these agricultural commodities. For the results briefly discussed below, several scenarios were simulated, based on the Shared Socioeconomic Pathways (SSPs) and Representative Concentration Pathways (RCPs) jointly developed by research communities under the Intergovernmental Panel on Climate Change (IPCC) initiative (Riahi, 2014). The SSPs are a set of narratives that together describe the alternative demographic and economic developments determinizing energy, land use and related trajectories globally; while the RCPs are trajectories of greenhouse gas concentrations. Simulations were carried out for 16 scenarios (Table 6); the scenario with moderate economic growth and no climate change assumed (alphabet codes A and C in Table 6) was selected as the baseline. All other scenarios were compared with the year 2010 and 2030/50 results for this baseline. IMPACT generates country-level outcomes of food production, demand, and prices. These are reported below, along with livestock feed demand linked to production. Food supply was used as a proxy for average consumption and intake (thus in effect using the three terms interchangeably). However, only food availability can be inferred from the aggregate data that are readily available (FAO national statistics and IMPACT measures).

In 2010, the supply of livestock derived foods in Ethiopia was around 76 kilocalories (kcal) on a per person per day basis (Table 7): 58 percent from meat, 39 percent from milk and 3 percent from eggs. Beef supply made up 72 percent of the 44-kcal per capita supply of meat. Under the baseline scenario, the supply of livestock-derived food increases to 85 kcal in 2030 and to 99 kcal in 2050. The share of meat increases slightly, from 58 percent in the base year to 61 percent in 2050. However, the share of beef declines while the shares of other meat types, i.e., lamb, poultry and pork, increase in the simulation years (pork <1 percent). The supply of lamb increases the most (at 11 percent) in relative terms. Although quantity of milk supply increases, its share in per capita supply of livestock-derived food declines from 39 percent in 2010 to 37 percent in 2030 and to 35 percent in 2050.

Table 6. Descriptions of IMPACT model scenarios included in the analysis (Enahoro et al., 2019).

Alphabet code	Scenario Code	Pace of economic growth	Year(s)	RCP simulation	Earth System Model (ESM)[1]
A	MiddleNoCC	Moderate	2010	None	none
B	FragmenNoCC	Slow	2030/50	None	none

C	MiddleNoCC	Moderate	2030/50	None	none
D	SustainNoCC	High	2030/50	None	none
E	FragmenGFDL_RCP_6.0	Slow	2030/50	6.0	GFDL
F	FragmenHGEM_RCP_6.0	Slow	2030/50	6.0	HADGEM
G	FragmenIPSL_RCP_6.0	Slow	2030/50	6.0	IPSL
H	FragmenMIRO_RCP_6.0	Slow	2030/50	6.0	MIROC
I	Middle GFDL_RCP_6.0	Moderate	2030/50	6.0	GFDL
J	Middle HGEM_RCP_6.0	Moderate	2030/50	6.0	HADGEM
K	Middle IPSL_RCP_6.0	Moderate	2030/50	6.0	IPSL
L	Middle MIRO_RCP_6.0	Moderate	2030/50	6.0	MIROC
M	SustainGFDL_RCP_6.0	High	2030/50	6.0	GFDL
N	SustainHGEM_RCP_6.0	High	2030/50	6.0	HADGEM
O	SustainIPSL_RCP_6.0	High	2030/50	6.0	IPSL
P	SustainMIRO_RCP_6.0	High	2030/50	6.0	MIROC

[1] GFDL or GFDL-ESM2M - National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamic Laboratory (www.gfdl.noaa.gov/earth-system-model); HADGEM or HADGEM2-ES - the Hadley Centre's Global Environment Model, version 2 (www.metoffice.gov.uk/research/modelling-systems/unified-model/climatemodels/hadgem2); IPSL or IPSL-CM5A-LR - the Institut Pierre Simon Laplace (http://icmc.ipsl.fr/index.php/icmc-models/icmc-ipsl-cm5); MIROC or MIROC-ESM - Model for Interdisciplinary Research on Climate, University of Tokyo, National Institute for Environmental Studies, and Japan Agency for Marin-Earth Science and Technology (www.geosci-model-devdiscuss.net/4/1063/2011/gmdd-4-1063-2011.pdf). From Robinson et al. (2015).

The IMPACT model projects an aggregate beef demand of 421,400 metric tons (MT) in Ethiopia in 2010. This is projected to increase to 678,500 MT in 2030 and 887,000 MT in 2050 under the baseline scenario, equivalent to an increase of 11 percent (from 2010) in 2050. In comparison, beef production increases by 88 percent from 2010 to 2050 and is higher than beef demand in 2050. Figure 7 shows beef demand and production for a variety of economic growth and climate change scenarios in 2050. While national production of beef is about 98 percent of national demand in 2010, production surpasses demand (by 10 percent to 55 percent) in 2050 under the different scenarios of economic growth and climate change, indicating that the country could well hold a net producer position for a range of macroeconomic changes. The gaps between aggregate demand and production are smallest (among the scenarios assessed) when assuming slower global economic growth (scenarios E, F, G, H in Table 6). Although slower growth seems to suppress production, aggregate national demand for beef is increased.

Table 7. Projections of the supply of different livestock-derived food types in Ethiopia in 2010, 2030 and 2050* (Enahoro et al., 2019).

	2010	2030	2050
	(kilocalories per person per day)		
Beef	31.51	33.95	34.65
Pork	0.14	0.23	0.39
Lamb	9.73	13.32	19.79
Poultry	2.41	3.57	5.54
Dairy	29.80	31.33	34.92
Eggs	2.12	2.89	4.19
All meats	43.80	51.07	60.37
Total	75.71	85.29	99.48

* IMPACT model results for moderate economic growth, no climate change (Middle No CC) scenario.

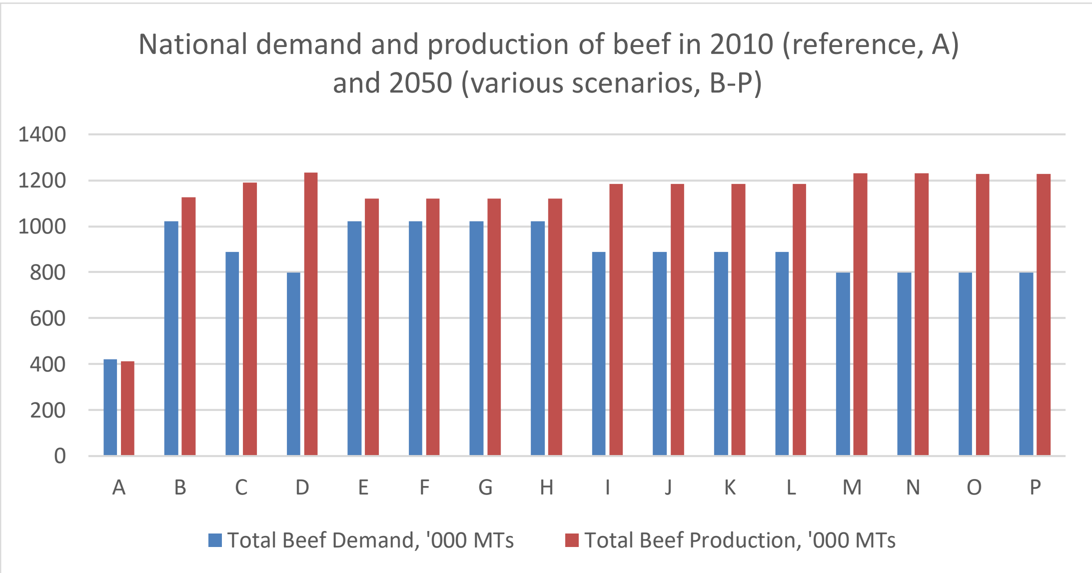


Figure 7. Model projections of demand and production of beef in Ethiopia

The model projections of net trade in beef are shown in Figure 8 for 2010, 2030 and 2050. Ethiopia is a net importer in 2010, by a small margin, and a net exporter in 2050 under all scenarios tested. Net export quantities are generally higher for the higher growth scenarios (i.e., M, N, O, P), lower for the slower growth scenarios (i.e., E, F, G, H), and in between for the moderate growth ones (i.e., I, J, K, L). As a block, the no-climate change scenarios of 2050 (i.e., B, C, D), present the most variability in net trade outcomes.

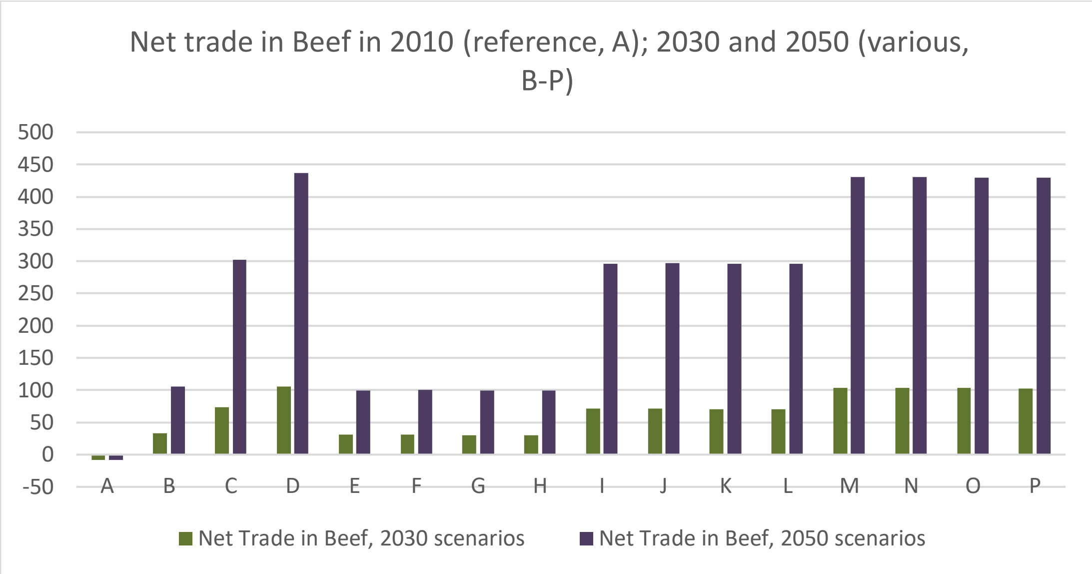


Figure 8. Model projections of net trade of beef in Ethiopia

Poultry is another sub-sector that is projected to change quite substantially. Under the baseline scenario, poultry demand increases by 121 percent in 2030 and 340 percent in 2050 relative to the base year estimates (Figure 9). Demand and production are highest when the global economy is faster growing (i.e., scenarios D, M, N, O, P), and lowest when slower (i.e., scenarios A, E, F, G, H). Poultry production does not meet anticipated demand under any of the scenarios tested. However, import quantity relative to demand does not vary much across the scenarios. Net poultry imports stand at between 28 percent and 30 percent of national demand under the different scenarios in 2050.

Projected changes in the demand and production of beef, poultry, and other livestock-derived food lead to substantially higher demand for livestock feed biomass (Figure 10). Under the baseline, the combined demand for cereals and oilseeds used as livestock feeds increases from 304,300 MT in 2010 to 608,900 MT in 2030 and 1,085,100 MT in 2050 (i.e., 100 percent and 357 percent change in 2030 and 2050, respectively). These projections of feed demand quantities reflect impacts of both future economic and climatic change and are more variable in 2050 than in 2030.

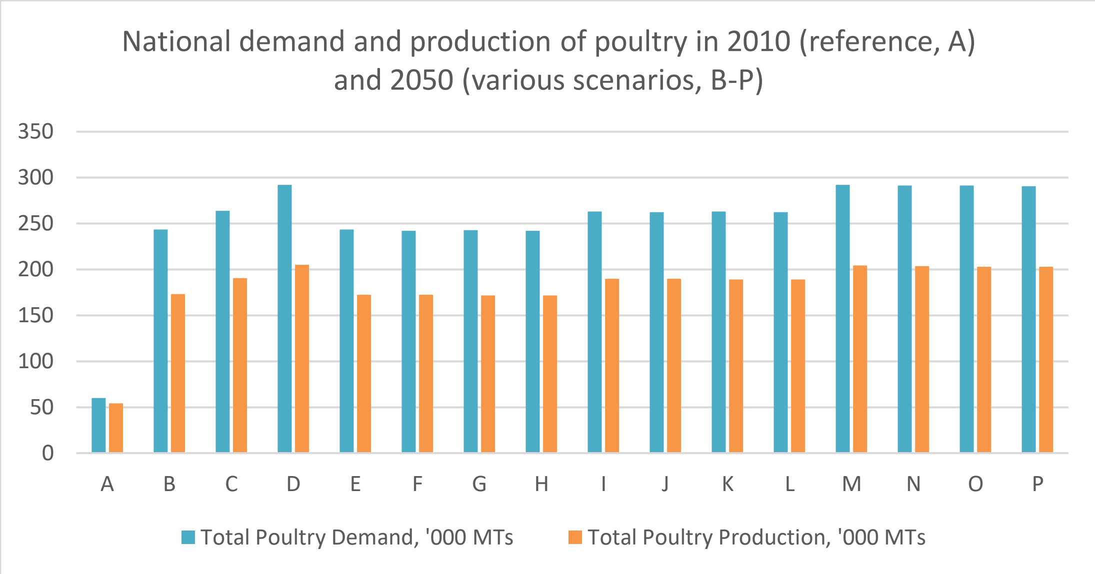


Figure 9. Model projections of demand and production of poultry in Ethiopia

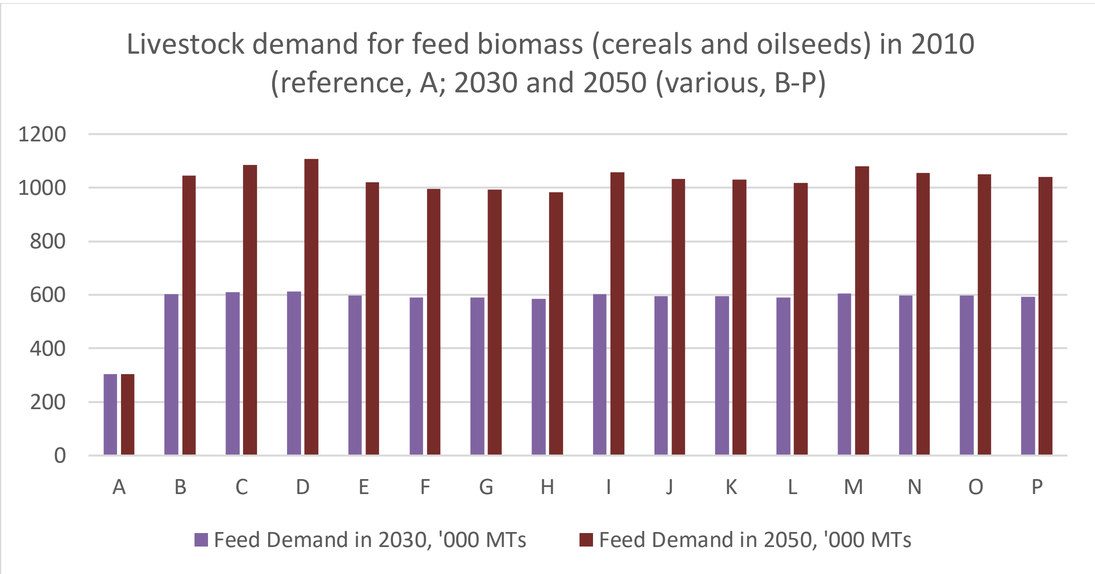


Figure 10. IMPACT projections of livestock feed demand in Ethiopia

IMPACT model simulations for Ethiopia showed a net producer position under the selected scenarios of macroeconomic change, consistent with the continued orientation of the country's livestock sector, as outlined in the country's livestock master plan, for example (Shapiro et al., 2015), towards policies that assume increased net exports of beef or live beef cattle. On the other hand, the plausible positive effects of a slower global economy on beef demand and production within Ethiopia are also important to note. These results reveal the important role of export markets in Ethiopia's beef sub-sector. As demand for beef exports from Ethiopia increases following rises in the global economy, higher prices will tend to dampen local consumption. Attention may thus need to be paid to such effects with continued export orientation of the sub-sector. Issues related to local beef prices, consumption of livestock-derived food, and health outcomes of nutritionally vulnerable groups such as the poor, women, and young children may need emphasizing (see Randolph et al., 2007). The analysis for Ethiopia raises issues related to the current capacity of local livestock production. Pressures will likely mount on livestock feeds and the management of natural resources needed for production such as land and water. There could be substantial benefits from investments in more effective feed storage and efficient feed marketing systems (Abegaz et al., 2007; Gebremedhin et al., 2009).

The IMPACT model results demonstrate relatively muted effects of climate change on the livestock sector at the national level for Ethiopia, given the assumptions made and the limitations of the modelling approach. This can be seen in Figures 7-10, for example, by comparing simulated results of the slow economic growth scenario baseline (B, with no climate change included) with the four "with climate change" scenarios (E, F, G, H, utilising different climate models; Table 6); of baseline D with scenarios M, N, O and P for the rapid economic growth simulations. There are several reasons for this. First, the climate change effects that are included in this modelling work to the 2030s, and even to the 2050s (changes in temperature and rainfall patterns and amounts), are themselves relatively modest under the GHG emission scenario used; it is only in the second half of the current century that temperature effects (in particular) become much more pronounced, with concomitant effects on livestock production and productivity. Second, the relatively aggregated nature of the results from the IMPACT model also hide what may be relatively high levels of spatial variability, i.e. between the higher-productivity livestock systems in the highlands compared with the arid-semiarid lowlands. Third, the shorter-term impacts of climate change on livestock systems, i.e. increased frequency and severity of extreme events such as drought and heat waves, are not captured in this modelling work. These reasons combine to indicate that the effects of climate change on livestock systems in Ethiopia to the middle of the century are being under-estimated.

Nevertheless, results do give some initial indications about areas in which policies that emanate from or affect the livestock sector in Ethiopia may need to evolve. The effects of higher local and global demand for ruminant animals and animal products, and of international trade in these commodities, need to be included in livestock, environment and land use policy design and implementation in the future. Concerns about food prices, poverty reduction, agricultural biodiversity and environmental sustainability, amongst others, will also be central in livestock sector planning. These issues are briefly returned to in section 7 below.

6. The national livestock policy environment

The Ministry of Agriculture, Livestock and Development sector oversees livestock nationally in Ethiopia. In 2013, the government established a livestock and fisheries ministry which was recently merged with Ministry of Agriculture and Natural Resources, to form the Ministry of Agriculture, Livestock Resources Development. Ethiopia also has a ministry of Environment, Forest and Climate Change. Major national policies affecting the livestock sector are outlined below.

Agriculture and fisheries: The Ministry of Agriculture (MoA) in Ethiopia was established in 1907, with the mandate to manage the agricultural and forestry sectors. Since 1991, the MoA has been leading the government policy of Agricultural Development Led Industrialization (ADLI) with the primary objective of accelerating national development and reducing poverty and food insecurity in rural areas.

Livestock: Under MOA, Ethiopia is currently implementing a Livestock Master Plan (LMP) launched in July 2015 (Shapiro et al., 2015). The LMP is the government blueprint for planned transformation of the livestock sector. Its goals are to strengthen the livestock sector, enhance nutrition and food security, improve resilience, and spur growth that will lift about 2.36 million households out of poverty by 2030. The LMP sets out targets for priority investments in options such as cross-bred dairy, meat and milk feedlot, and poultry development, that are expected to make big differences.

Environment: One of the major policy documents guiding environmental management in Ethiopia is the Environmental Policy of the Federal Democratic Republic of Ethiopia that was approved by the Council of Ministers in April 1997. The general objective of this policy is to ‘improve and enhance the health and quality of life of all Ethiopians and to promote sustainable social and economic development through the sound management and use of natural, human-made and cultural resources and the environment to meet the needs of the present generation without compromising the ability of future generations to meet their own needs’. Chapter three of the Policy document discusses the environmental impacts of Ethiopia’s livestock production systems.

Climate: The Climate-Resilient Green Economy Strategy of Ethiopia was developed through an initiative led by the Prime Minister’s Office, the then Environmental Protection Authority, and the Ethiopian Development Research Institute. The Ministry of Environment, Forest and Climate Change is the lead organization for overseeing the implementation of this strategy. The objective of the strategy is to identify green economy opportunities that could help Ethiopia reach its ambitious growth targets (which are stipulated in the Growth and Transformation Plan) while keeping greenhouse gas emissions low. The strategy is currently being implemented and will require a boost in Ethiopia’s agricultural productivity, strengthening the industrial base and fostering export growth. The Ethiopian climate resilient green economy strategy (2011) has four initiatives for a climate resilient green economy (CRGE). One of these initiatives is to improve efficiency in the livestock value chain.

Ag-Biodiversity: Ethiopia has a revised National Biodiversity Strategy and Action Plan 2014 which acknowledges the role of the country as a gateway to domestic animals transported from Asia to Africa. Majority of Ethiopia's livestock are indigenous, with few exotic breeds imported in recent years (last four decades). Indigenous breeds are considered threatened due to interbreeding or changes in production system, while the National Biodiversity Strategy highlights the lack of up-to-date breed level statistics. Formulated against the backdrop that biodiversity conservation will be a key condition for attaining overall socioeconomic development and sustainable environmental management, the National Policy on Biodiversity Conservation and Research issued in April 1998 provides a general framework towards effective conservation, rational development, and sustainable utilization of genetic resources. Ethiopia's indigenous genetic resources include a variety of animal and plant species, the most common of which are mammalian (cattle, sheep, goats, camels, donkeys, horses and mules), avian (poultry, ostrich and turkey) and honey bees. The country also has a broad range of pasture and forage resources.

The next subsection discusses policy coherence in Ethiopia and is taken from Ashley (2019).

Policy coherence

While Ethiopia's climate policies support substantial livestock adaptation and mitigation strategies, they are in somewhat in contrast to livestock policies aimed at sector growth. Policies do not necessarily contradict one another but climate policy is more ambitious in achieving emissions reduction in the livestock sector. If climate policy emissions reduction strategies are not adequately implemented, sectoral growth and the associated emissions could jeopardise the country's NDC and GTP II commitments for GHG emissions reduction in the agriculture sector.

In terms of policy implementation, Ethiopia's governance is shared between the national and nine regional governments. The country's decentralised approach extends policy oversight and involvement to regional, district (woreda), and local (kebele) levels. There are CRGE governance structures in place at national, regional, and woreda levels that are envisioned to support both mitigation and adaptation action (NAP, 2019). Ethiopia's Ministry of Agriculture is a key institution in these structures and overall CRGE implementation. While Ethiopia has been at the forefront of climate policy for low-income countries and has established relevant governance structures, some research has shown that policy implementation is limited, particularly in rural areas (Paul and Weinthal, 2018).

Climate policies in Ethiopia have aimed to raise the profile of climate action through institutional, capacity, and planning initiatives. The prominence of the CRGE Strategy, its integration of the livestock sector, and livestock and development policy alignment with the CRGE are key enabling conditions. Further, the Climate Investment Funds Pilot Programme for Climate Resilience (PPCR) in Ethiopia has focused on agriculture and forestry. The PPCR investment plan is manifest as the Multi-Sector Investment Plan (MISP) for Climate Resilient Agriculture and Forest Development, 2017-2030. The Plan strongly integrates livestock sector adaptation and mitigation and identifies specific financing sources for activities.

The policies reviewed by Ashley (2019) discuss a range of enabling and disabling conditions for climate adaptation and mitigation in the livestock sector. The LMP provides detailed descriptions of challenges for implementation and strategies to overcoming them which are applicable across policy areas and adaptation and mitigation strategies. Some challenges to implementation include:

- Limited access to land for production of forage and forage seed,
- Inadequate and poor access to quality forage seed and cuttings;
- Insufficient extension and animal health services,
- Inadequate supply and poor-quality control of drugs and veterinary supplies,
- Inefficient AI services,
- Low productivity of local breeds and a low number of improved genotypes, and
- Very high calf mortality.

In terms of improving enabling conditions for climate resilience in the livestock sector, the MISF provides specific recommendations including:

- Implementation of the newly developed Animal Breeding Policy should consider future climate scenarios and prioritise those characteristics that will allow higher yields under uncertain conditions and increased temperatures.
- Ensure that land use planning guidance considers strategic feedlot creation alongside irrigation for agriculture to preserve the integrity of extensive grazing systems.
- Review policies impacting livestock feed and create incentives for domestic feed production, including limiting the oilseed export, encouraging domestic grain production, and integrating livestock feed production in newly developed Agro-Industrial Park Clusters.
- Greater investments in research and development for livestock production systems in areas with a high level of vulnerability to climate change.

The Draft Pastoral Development Policy and Strategy indicates that underdevelopment in pastoral areas is related to gaps in government policies and strategies, a view of pastoralism as a backward livelihood system, practices that have restricted pastoralists' mobility, and absence of relevant development plans. The policy also notes that failure to recognize customary and communal management systems has undermined them and led to natural resource degradation. Alternatively, the policy notes a range of government efforts have aimed to support pastoralists although these have not resulted in adequate development. These efforts include the right to self-administration and special support granted under the Constitution, which has led to institutional arrangements such as the Standing Committee that looks after the affairs of Pastoral Development in the House of Peoples Representatives, the Federal and Pastoral Development Affairs Ministry, and the Federal Special Support Board. Other policies have noted reluctance among pastoralists to switch to improved breeds or reduce herd size as a constraint.

Ethiopia's climate and development policies are strong and coherent on livestock sector adaptation and mitigation measures. There is particular coherence among the country's CRGE Strategy, development policy (GTP II), NDC, and NAP. Livestock and agriculture policies are weaker on attention to climate- livestock issues although the LIP sets out an approach for mitigation in the dairy and poultry value chains. The Draft Integrated Land Use Policy could be a key document for facilitating livestock sector adaptation and mitigation but does not adequately integrate climate and livestock issues.

Ashley (2019) examined each policy area for integration of livestock sector climate change adaptation and mitigation and alignment with the Sustainable Development Goals (SDGs; UN, 2015) and national development goals. Policies were scored for extent of integration of livestock sector adaptation and mitigation, and results are summarised in Table 8. Higher scores designate more dedicated and detailed climate related strategies for the livestock sector.

Table 8. Ethiopia policy integration of livestock sector adaptation and mitigation summary (Ashley, 2019).

Ethiopia	Livestock Adaptation score	Livestock Mitigation score
Climate Policy		
Climate Average	2.5	2
NAPA, 2007	2	2
Climate Resilient Green Economy Strategy, Green Economy Strategy, 2011	1	3
Climate Resilient Green Economy (CRGE), Climate Resilience Strategy, 2014	3	2
NDC, 2015	3	1
Multi-Sector Investment Plan (MISP) for Climate Resilient Agriculture and Forest Development (PPCR), 2017- 2030	3	3
NAP (Climate Resilient Green Economy Strategy), 2019	3	1
Livestock & Agriculture Policy		
Livestock & Agriculture Policy Average	1	1.33
Agricultural Sector Policy and Investment Framework (PIF), 2010-2020	1	1
Livestock Master Plan, 2015	1	1
Livestock Investment Implementation Plan, 2015-2030	1	2
Development Policy		
Development Average	3	3
Growth and Transformation Plan II (GTP II), 2016-2020	3	3
Land & Environment Policy		
Land & Environment Average	1	1
Environment Policy, 1997	1	1
Draft Integrated Land Use Policy, 2019	1	1

From this analysis, Ashley (2019) identified several opportunities for engagement with climate-livestock policy in Ethiopia, in relation to synergies, gaps and potential conflicts.

Strongest synergies across policies:

- Ethiopia's climate (CRGE Strategy, NDC, and NAP) and development (GTP II) policies provide strong and coherent strategies for livestock sector adaptation and mitigation.
- The Livestock Master Plan (LMP; Shapiro et al., 2015) includes remarkably brief reference to climate change but does state that its interventions were assessed according to GTP objectives including contribution to climate change mitigation and adaptation. While it does not include explicit adaptation or mitigation strategies, the LMP's detailed approach and activities for improved breeding, feeding, disease control, pasture management, and soil and water conservation could go further in building climate resilience and limiting emissions than some dedicated, but less detailed, climate-livestock strategies. More explicit attention to climate issues in implementation could facilitate this. The Livestock Investment Implementation Plan (LIP) aims to build on the LMP by strengthening mitigation action.

Key gaps

- Across policy areas there is almost no reference to climate-smart agriculture (CSA). While many strategies align with a CSA approach, more explicit engagement with a CSA approach could facilitate adaptation and mitigation co-benefits and sustainable sector growth. In the absence of a CSA approach, dedicated livestock mitigation strategies such as breeding for increased productivity could inadvertently lead to adverse impacts on livestock climate resilience.
- The Draft Integrated Land Use Policy, 2019, could be a key document for facilitating livestock sector adaptation and mitigation but does not adequately integrate climate and livestock issues. There are hopes that it will be an integral part of the country's Third Growth and Transformation Plan (GTP III), 2020-2024. While the policy supports overall resilience in the livestock sector and among pastoralists and agro-pastoralists, there is no direct reference to climate impacts to livestock or adaptation or mitigation action.

Potential conflicts

- The Environment Policy, 1997, largely portrays livestock as a driver of land degradation that has resulted in lost agricultural production and diminished agricultural potential. While the current development policy, including the Draft Pastoral Development Policy, now includes a much more nuanced view of livestock, some strains of the Environment Policy view may remain. The GTP II, for example, references the livestock sector's dependence on "backward production methods." If implementation of the GTP II results in overemphasis on intensifying livestock sector production, there could be a missed opportunity to achieve livestock sector adaptation and mitigation ambitions among the pastoral systems that account for much livestock production.

7. Conclusions: system intervention points

Ethiopia's livestock sector faces several challenges in the coming years. Demand for livestock-derived food is projected to increase by 100-200 percent, depending on product, to the middle of the century, as the country's population rises to 190 million by 2050 and the number of people living in urban areas triples. Projections indicate that Ethiopia will move towards being a net exporter of beef or live beef cattle, though higher local prices following rises in the global economy may dampen local consumption, with potentially deleterious effects on health outcomes of nutritionally vulnerable groups such as the poor, women, and young children. Demand for milk, poultry meat and eggs are projected to increase substantially too. National livestock production capacity may be stretched, particularly with respect to livestock feeds and the management of natural resources such as land and water. The demand for livestock feed may double by 2030 and quadruple by 2050. Investments in effective feed storage and efficient feed marketing systems could reap large benefits.

There is relatively little literature on the national impacts of climate change on Ethiopian livestock production, though regional and continental analyses from the IPCC and other sources show clearly what can be expected. Increased frequency and severity of extreme events such as drought and heat will increasingly test the resilience of livestock keepers and their animals, particularly in the pastoral and agropastoral lands. Substantial knowledge gaps exist on the impacts of climate change on non-ruminants, its potential effects of water availability in livestock systems, and effects on zoonotic and other livestock diseases. Preliminary research suggests that rising temperatures will result in marked increases in heat stress in cattle. Such considerations highlight the need for characterisation of species and breeds of livestock that may have high adaptive capacities to climate change.

At the same time, a wide range of adaptation options is available, particularly to address increasing climate risk, and many of these have mitigation co-benefits. Targeting these at broad scale is challenging because of the variation in local agro-ecological and socio-economic contexts. In addition, there are several barriers to widespread uptake of livestock interventions in Ethiopia, including inadequate access to appropriate finance for livestock keepers, to extension services, and to market information, as well as issues around land tenure, for example.

With respect to the policy and enabling environment, several opportunities exist for engagement with climate-livestock policy in the country. Ethiopia's climate and development policies provide strong and coherent strategies for livestock sector adaptation and mitigation. Although the Livestock Master Plan does not include explicit adaptation or mitigation strategies, its treatment of improved breeding, feeding, disease control, pasture management, and soil and water conservation provide a strong foundation for further action in building climate resilience, limiting

GHG emissions, and addressing some of the environmental interactions with a production focus that may arise. As the LMP is implemented, there would appear to be good opportunities to strengthen mitigation action as well as to increase coordination across different ministries to manage the outcomes of livestock sector transitions. Across policy areas there is almost no reference to CSA, and more explicit engagement with a CSA approach could facilitate adaptation and mitigation co-benefits and sustainable sector growth. The Draft Integrated Land Use Policy of 2019 could be a key document for facilitating livestock sector adaptation and mitigation; while climate and livestock issues are not that well integrated, there are hopes that it will be an integral part of the country's Third Growth and Transformation Plan (GTP III), 2020-2024.

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