Program for climate-smart livestock systems

Country stocktake: Kenya

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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 Kenya are 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 Kenya. 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 Kenya.

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 Kenya. Section 2 summarises information on the prevailing livestock systems in the country, along with their baseline performance. The livestock systems in the PCSL study region 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 Kenyan 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 Kenya. 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

Kenya has the largest, most diversified economy and the second largest population (about 50 million people) in East Africa. The country has become a leader in mobile-money and information-and-communication technology. Kenya's economy grew 5.0 percent on average annually from 2008 to 2017, marking an important increase from the 2.7 percent to 3.8 percent annual increases averaged over the two decades prior. Its rural population in 2017 was 73 percent of the total population, down (slightly) from 78 percent ten years earlier. Nearly 9 million poor livestock keepers live in Kenya, or 28 percent of its rural population (Table 1a). Livestock production is a major agricultural activity in Kenya, with the livestock sector contributing 30 percent of agricultural GDP and about 12 percent to the national GDP. The livestock sub-sector further accounts for 30 percent of total marketed agricultural products and employs 50 percent of the total agriculture labour force. Cattle and small ruminant animals are of high importance in Kenya (e.g., to human diets and economics). A national census carried out by the Kenyan National Bureau of Statistics in 2009 reported live animal stocks of 17.5 million cattle, 17 million sheep, 28 million goats and 3 million camels; while FAO statistics record 18 million cattle, nearly 19 million sheep, and more than 24 million goats for Kenya currently (Table 1b). The main ruminant livestock breeds kept are East African Zebu, the Boran cattle, East Africa goats, the Galla goats, Red Maasai, Black Head Somali sheep and the one hump camel.

Poultry is of growing importance in Kenya. There are around 48 million poultry birds, with many indigenous poultry as well as exotics and cross-breds. The sector is highly heterogeneous, comprising of a large number of small scale free-range and backyard indigenous chicken producers; a good number of small-scale commercial layers and broiler farms; and a few industrial integrated layer and broiler farms (ASL, 2018). Chickens constitute about 98 percent of the total poultry raised in Kenya and it has been estimated that 65 percent of Kenyan households keep at least one bird (Omiti and Okuthe, 2009).

Other than poultry, there is a wide variety of livestock production system in Kenya, broadly categorized as extensive, intensive (which is usually commercially oriented), and semi-intensive (common among small scale dairy, poultry, pig, rabbit and feedlot beef producers). Extensive systems are mostly made up of the rangelands, with either organized grazing or nomadic pastoralism, and these systems support about 70 percent of the ruminant livestock population. Both pastoralism and ranching are categorized as extensive systems.

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

Table 1a. Selected macro-indicators

Total human population (million)	Rural population (% total)	Poor livestock keepers (% rural population)	Annual GDP per capita (USD)	GDP growth (% annual, 2017)	Population growth (% annual, avg. 2008-2017)
49.7	74%	28%	1507	4.9	2.5

Sources: World Bank Indicators (World Bank, 2019), data for 2017. 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, 2017)				
			Cattle	Sheep	Goats	Pigs	Poultry birds
30.0	27.5	8.0	18.33	18.76	24.68	0.55	48.12

Source: 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 (%)
660.27	5,010.66	114.38	12.9	26.3	11.0

Sources: data on prevalence of underweight is a 3-year average (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
919,000	7,284,000	786,000	8,990,000

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

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).

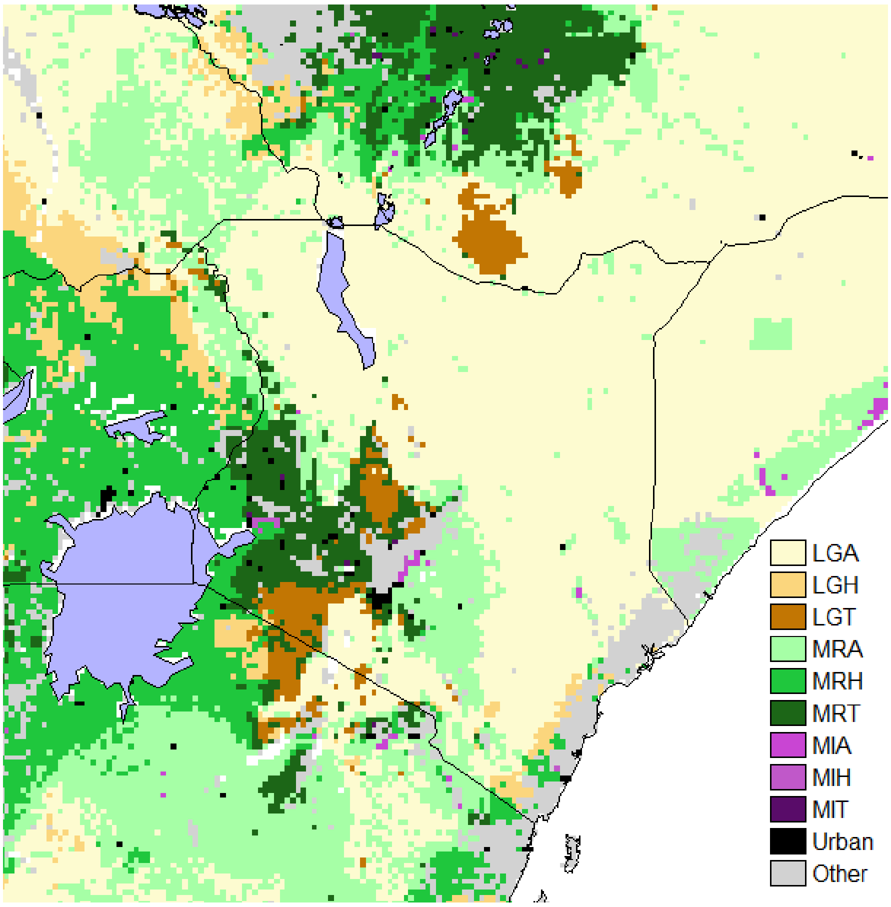


Figure 1. Livestock systems of Kenya, according to the classification of Sere and Steinfeld (1996) mapped in Robinson et al. (2011).

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.

The livestock systems in Figure 1 can be broken down into dairy production and beef systems. Dairy cattle production in Kenya is the second largest contributor to agricultural GDP, and the country produced over 4.48 billion litres of milk in 2014 valued at KES 243 billion (USD 2.4 billion), of which 76 percent is from cows and the rest from camels and dairy goats (FAOSTAT, 2019). Per capita consumption is about 117 litres of milk per year, one of the highest levels in Africa. The dairy sector is a major source of employment in rural areas and small-scale farms produce about 80 percent of the total milk in the country. Some general characteristics of Kenyan diary systems are shown in Table 2.

Table 2. Short description of dairy cattle production systems in Kenya (Staal et al., 2001; ASL, 2018).

Production system	Short description	Proportion of farms (%)
Large-scale intensive (zero grazing)	Confinement of animals, a high level of management and optimum feed resource planning. Large-scale operations with > 15 cows. Milk yields 15-30 l per cow per day, milk sold mostly to processors and large cooperatives.	5
Small-scale intensive (zero grazing)	Confinement of animals, a high level of management and optimum feed resource planning. Small-scale operations with 1-15 cows. Milk yields 15-30 l per cow per day, milk sold mostly to cooperatives and middle men, with some for home consumption.	35
Semi-intensive (semi-grazing, mixed MR)	Animals are partly confined and allowed to graze freely or under paddocking and enclosed in the evening, when feed supplementation is provided. Dairy cattle often raised together with chicken, sheep, goats, donkeys and sometimes pigs. Milk yields < 6 l per cow per day, home consumed and sold informally.	45
Extensive controlled (LG)	A pasture-based production system dominated by exotic breeds and crosses of indigenous breeds. Practiced in areas with large farms (>50 animals). Milk yields 4-11 l per cow per day.	10

Extensive uncontrolled (LG)	A pasture-based production system dominated by exotic breeds and crosses of indigenous breeds, practiced in marginal and communal grazing lands. Milk yields 4-11 l per cow per day.	5

The beef industry is the largest contributor to agricultural GDP in Kenya (about 35 percent) and like the diary sector, is an important contributor to the Kenyan economy in terms of value and employment, especially in the arid and semi-arid lands where beef production from pasture is the main economic activity. Beef systems can be classified as extensive grazing (both pastoralism and ranching), semi-intensive grazing system (agro-pastoralism) and intensive (feed lot). Some characteristics are shown in Table 3 (ASL, 2018).

Table 3. Short description of beef production systems in Kenya (ASL, 2018).

Production system	Short description	Proportion of farms (%)
Extensive pastoralism (LG)	A subsistence system, low input-low output. Transhumance and nomadism are practiced. Indigenous beef cattle breeds dominate and are kept in mixed herds with other animals. Herd size averages 50 animals. Meat sold mostly in live animal markets.	34
Extensive ranching (LG)	A highly commercial system targeting prime local niche and export markets. There are fewer than 100 ranches in the country, all with large land areas and average herd sizes of 150 animals (exotics, crosses and Zebus). Quite labour intensive, and most ranches have infrastructure for disease control, feeding and water storage.	11
Semi-intensive (MR)	Mixed systems that use crop residues and by products as feed for the livestock, and manure and draught power to aid crop production. Low input-low output. Average herd size is 10-12 animals, mainly crossbreeds and exotics. Animals graze extensively in communal grazing lands or in paddocks.	54
Feed lot	A commercially-orientated beef system in which animals are kept for about 3 months and fattened to be sold to prime beef markets. Capital and labour intensive. Currently very few such operations in Kenya, with herds of 500-3000 animals. These systems have high biosecurity practices and optimal veterinary service practices.	1

The study regions identified for PCSL project activities in Kenya include sites in five counties in the south-west and southern parts of the country. Some household characteristics from Nyando County using existing survey data are shown in Box 1, and for Nandi and Bomet Counties in Box 2.

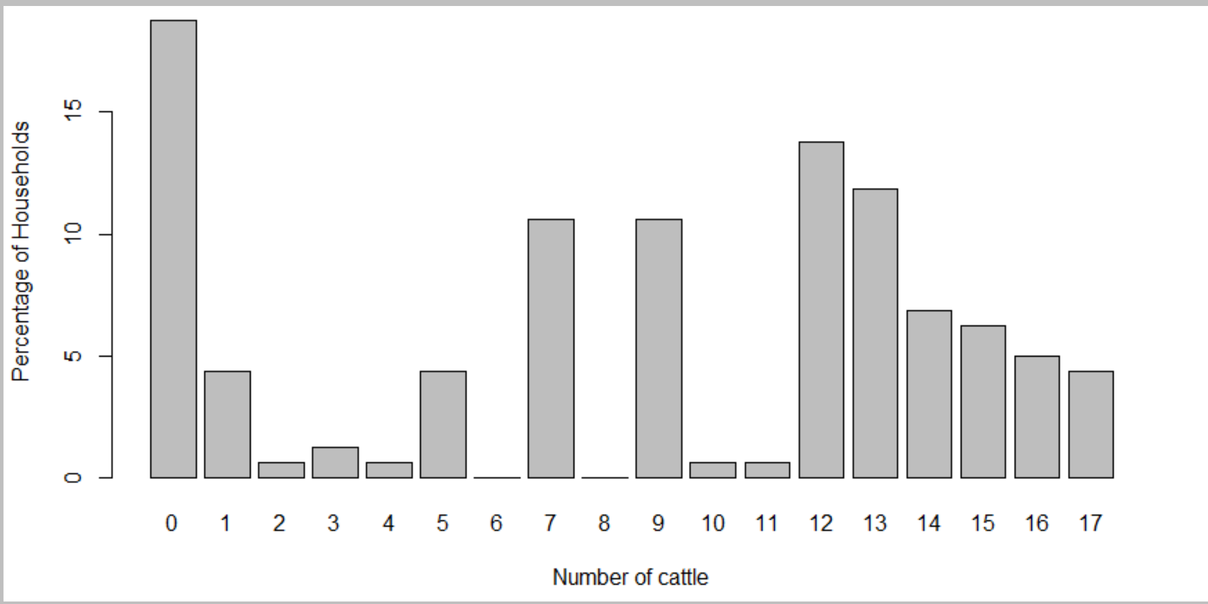
Box 1. Data summary sheet, Nyando

A. Key information

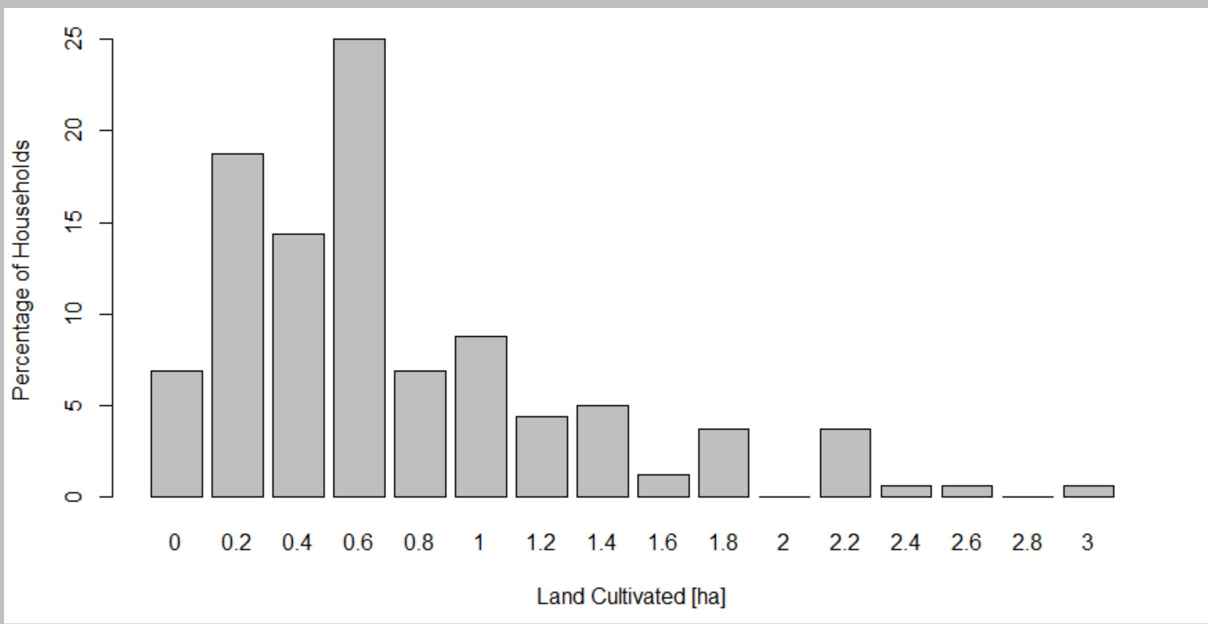
Variable	Value
Average farm size [ha] (stdev)	0.91 (0.6)
Average livestock holding [tlu]	8.2 (4.5)
Average number of cattle	9.6 (5.9)
Average number of chicken	9.1 (6.9)
Average number of goats	7.5 (8.1)
Total farm income generated [USD PPP corrected per household per yr]	1330 (1980)
Total livestock income generated [USD PPP corrected per household per yr]	880 (1283)
Total value of livestock produce consumed [USD PPP corrected per hh per yr]	516 (441)
Average milk production per cow (l/producing animal/day)	2.1 (3.2)
Milk production per cow of 10% best producing farms (l/producing animal/day)	9.1 (5.8)
Average egg production per chicken	0.32 (0.34)
Egg production per chicken of 10% best producing farms	1.02 (0.45)

Source of information: RHoMIS (Rural Household Multiple Indicator Survey; www.rhomis.org) application in Nyando, Kenya in 2016; 162 household were surveyed in the CCAFS benchmark site; a re-survey of households surveyed in 2012 as well.

B. Distribution of cattle holdings per household



C. Distribution of cultivated land size per household



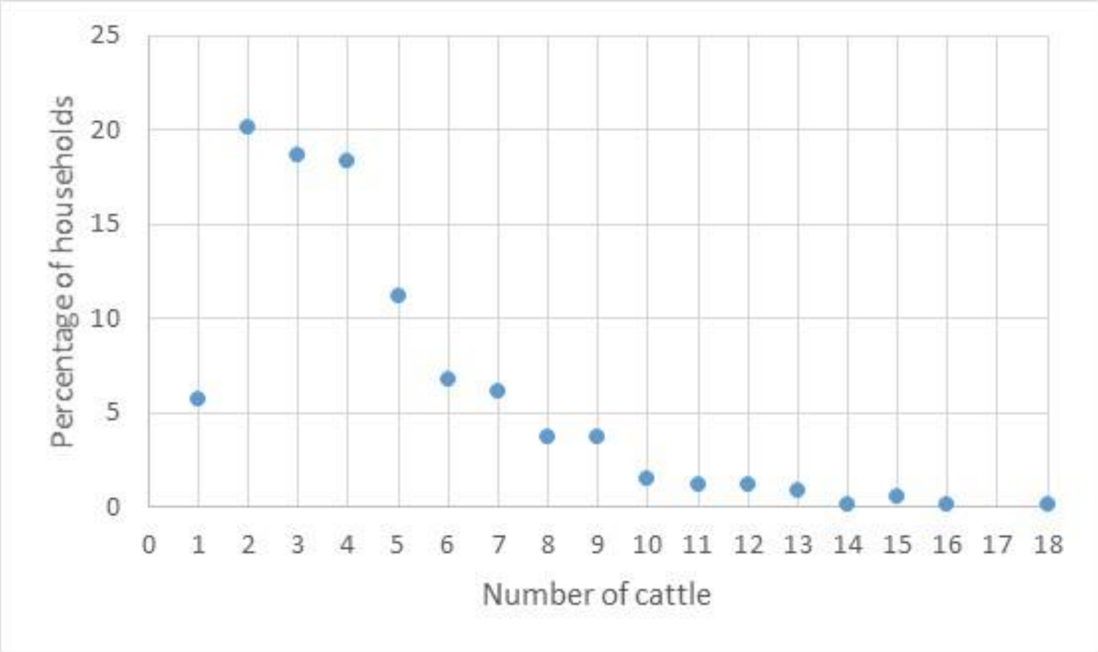
Box 2. Data summary sheet, Bomet and Nandi

A. Key household information (N=671)

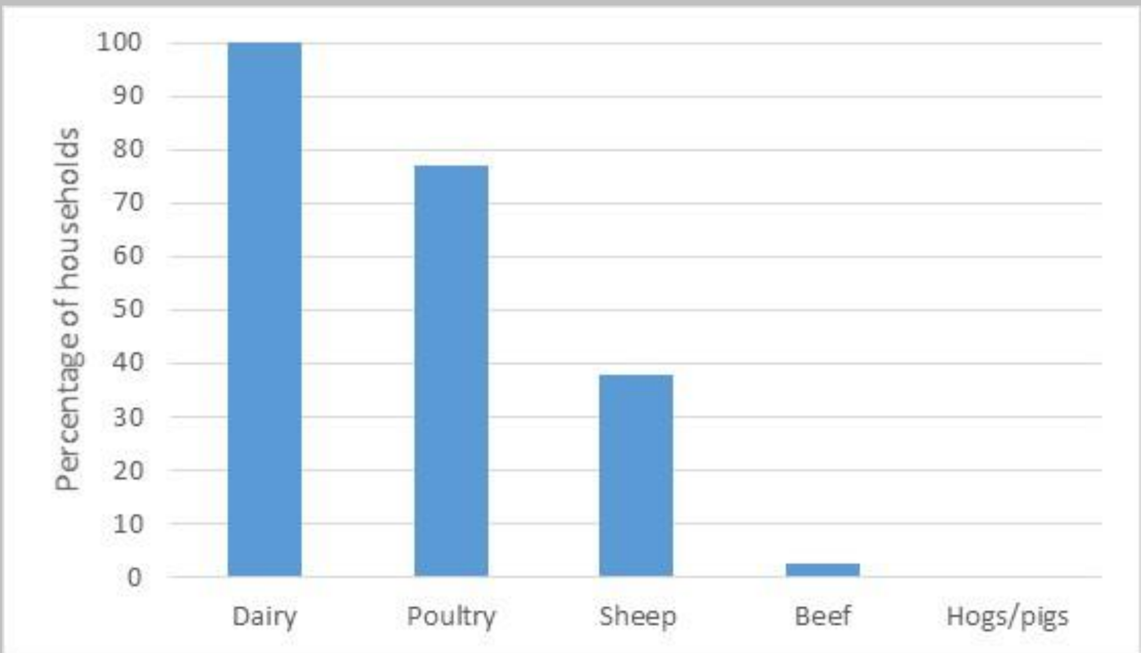
Variable	Value
Average plot size [acres] (stdev)	4.6 (4.7)
Average livestock holding [tlu]	3.9 (2.6)
Average number of cattle	4.5 (2.8)
Average number of cows	2.0 (1.2)
Average number of chickens	10.1 (12.9)
Average number of shoats	1.7 (3.7)
Average number of pigs/hogs	0 (0)
Average total livestock (without milk) income per hh per year	KES 42279 (13,927)
Average total milk income generated per household per year	No accurate data for Bomet
Average daily milk consumption per household in dry season (L/day)	2.7 (1.9)
Average daily milk consumption per household in wet season (L/day)	3.5 (2.3)
Average milk production per cow (L/cow/day)	5.7 (3.2)
Milk production per cow of 10% best producing farms (L/cow/day)	12.1 (3.1)
Asset index (Filmer and Pritchett, 2001)	-1.79 (6.06)

Source: Survey data from 341 (Bomet) and 330 (Nandi) households, from the Greening Livestock survey, 2017- 2018.

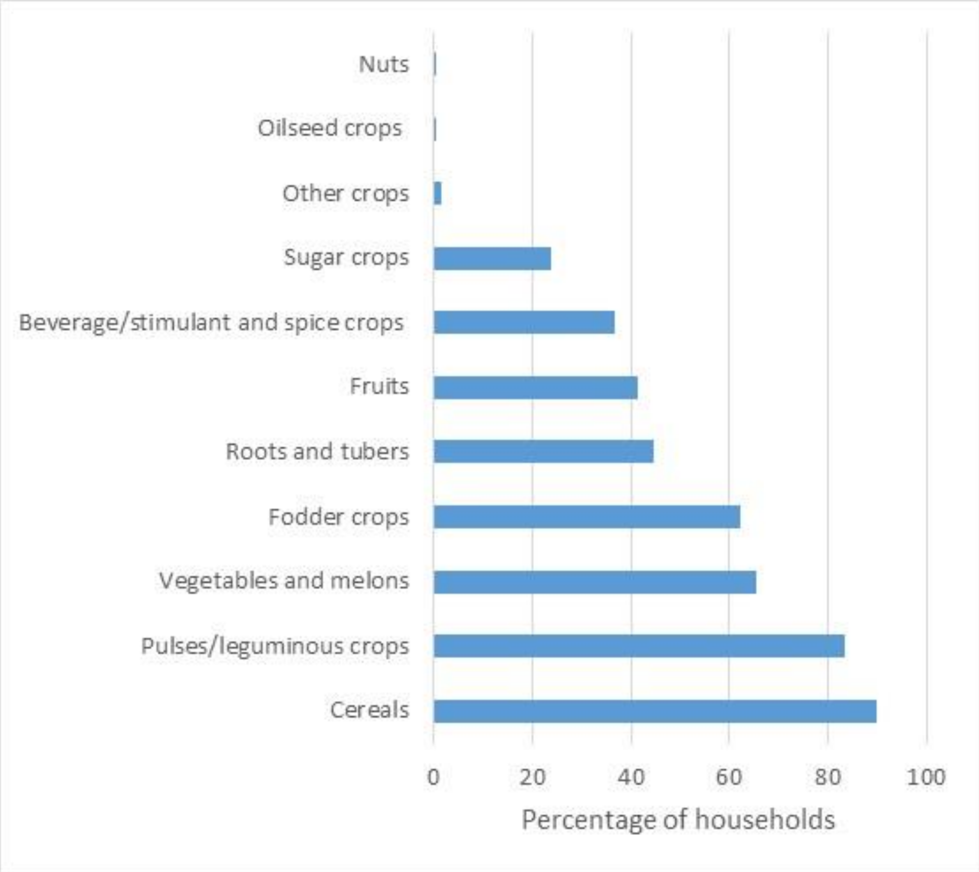
B. Distribution of cattle holdings per household



C. Household engagement in livestock activities in the last 12 months



D. Household engagement in cropping activities in the last 12 months



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

Kenya's average annual temperature increased by 1 °C between 1960 and 2003, though this hides considerable variation: temperatures in western Kenya rose by 0.5 °C between 1981 and 2004, while in the drier parts of the country, temperatures went up by 1.5 °C during the same period (CIAT, 2017). Seasonal rainfall trends vary greatly across agro-ecological zones, though overall, the data indicate increases in total annual precipitation by about 0.2 to 0.4 percent per year. Extreme climate events have become increasingly frequent in recent years, with direct consequence for annual agricultural production. About 98 percent of agriculture in Kenya is rainfed and thus highly vulnerable to increasing temperatures, shifting rainfall patterns and amounts, and droughts and floods. Smallholder farmers can be particularly hard hit. The 1998 El Nino and the 2009 drought resulted in combined losses of US$2.8 billion (about 7 percent of the 2010 GDP equivalent), with crops and livestock bearing the brunt of the losses (MENR, 2009).

Projections based on the RCP 4.5 emissions scenario suggest further increases in mean annual temperature of 1 °C to 1.5 °C by 2030, along with changes in rainfall distribution and more frequent extreme events, such as prolonged drought and flooding. Rainfall increases are projected to occur in the area from the Lake Victoria region to the central highlands east of the Rift Valley. The eastern and northern arid and semiarid lands are projected to see an overall decrease in rainfall to the middle of the century, although projections of rainfall shifts in East Africa in general are highly uncertain.

As for most regions of sub-Saharan Africa, climate change will bring shifts in the suitability of different crops. Under higher GHG emissions scenarios, beans are likely to see a drastic decrease in suitable area, for example (Ramirez-Villegas and Thornton, 2015). And while maize is the preferred crop in many farming systems in Kenya, it is not a well-adapted crop for current climatic conditions, nor is it well-suited under future projected climate conditions. Climate change will likely have major implications for maize production, with losses estimated at US$100–200 million annually by 2050 (CIAT, 2017). However, there are some areas of Kenya where opportunities for crop diversification and intensification may emerge as a result of the changing climate, including options for expanding into places where cultivation is not currently possible (Ramirez-Villegas and Thornton, 2015).

For the livestock systems, 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 Kenya, preliminary analyses indicate that heat stress in cattle may become a widespread and serious problem, particularly for dairy systems, 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 some of the climate hazards in Kenya 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.

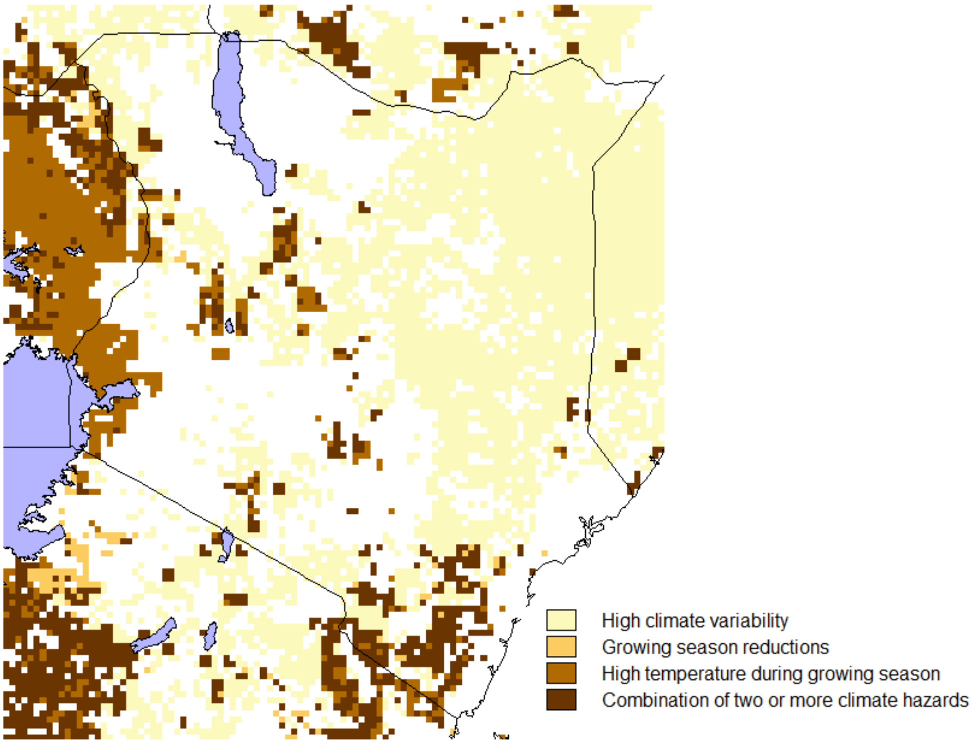
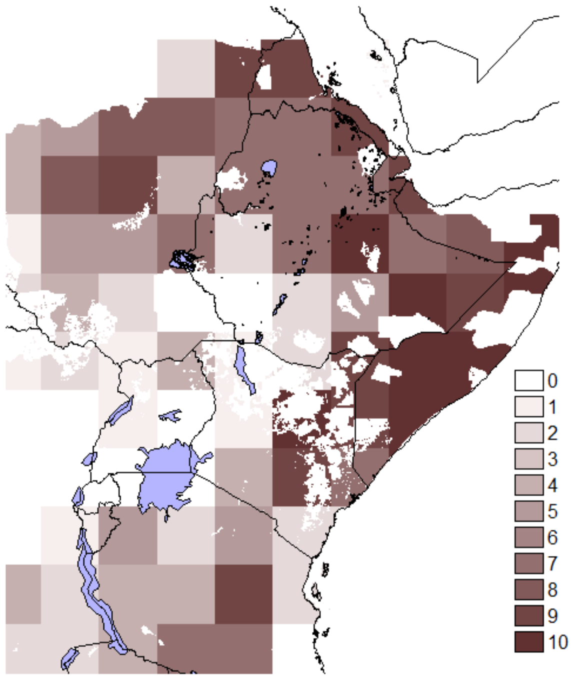


Figure 2. Areas of high agricultural risk for selected climate hazards in vulnerable areas of Kenya (from Thornton et al., 2019).

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.



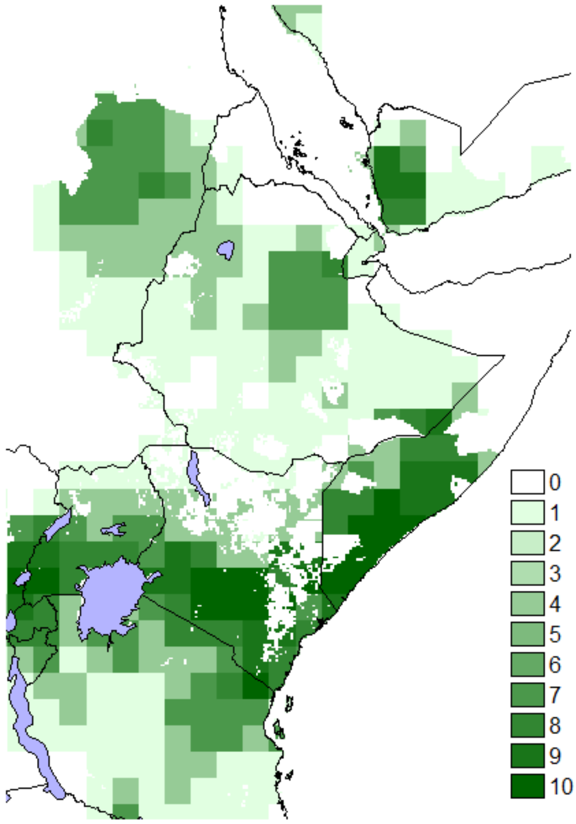


Figure 3. **Top**: drought risk, 1989-2000, deciles (1 low, 10 high). Source: Dilley et al. (2005), CHRR/CIESIN/IRI (2005)

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

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 sites in Kenya with respect to agro-ecological zone, livestock system, and the climate hazards shown in Figure 2 and Figure 3. The locations of the selected countries are shown in Figures 4 and 5.

Table 4. PCSL intervention counties in Kenya.

Site	Country	Predominant Agro-Ecological Zone(s)	Livestock system	Climate hazard(s)
1	Nandi	Lower Highland – Humid, Lower Highland – Sub-humid	Mixed rainfed crop-livestock (MRH) / agro-pastoral	High temperatures Low drought risk High flood risk
2	Bomet	Upper Midland – Humid, Lower Highland – Sub-humid, Upper Midland – Sub-humid	Mixed rainfed crop-livestock (MRT) / agro-pastoral	Low drought risk High flood risk
3	Nyando	Lower Midland – Sub-humid, Lower Midland – Semi-humid	Mixed rainfed crop-livestock (MRH) / agro-pastoral	High temperatures Low drought risk High flood risk
4	Kajiado (Magadi)	Lowland – Semi-arid	Pastoral (LGA)	Climate variability Medium drought risk High flood risk
5	Kajiado (Olkeramatian)	Lowland – Arid	Pastoral (LGA)	Climate variability Medium drought risk High flood risk

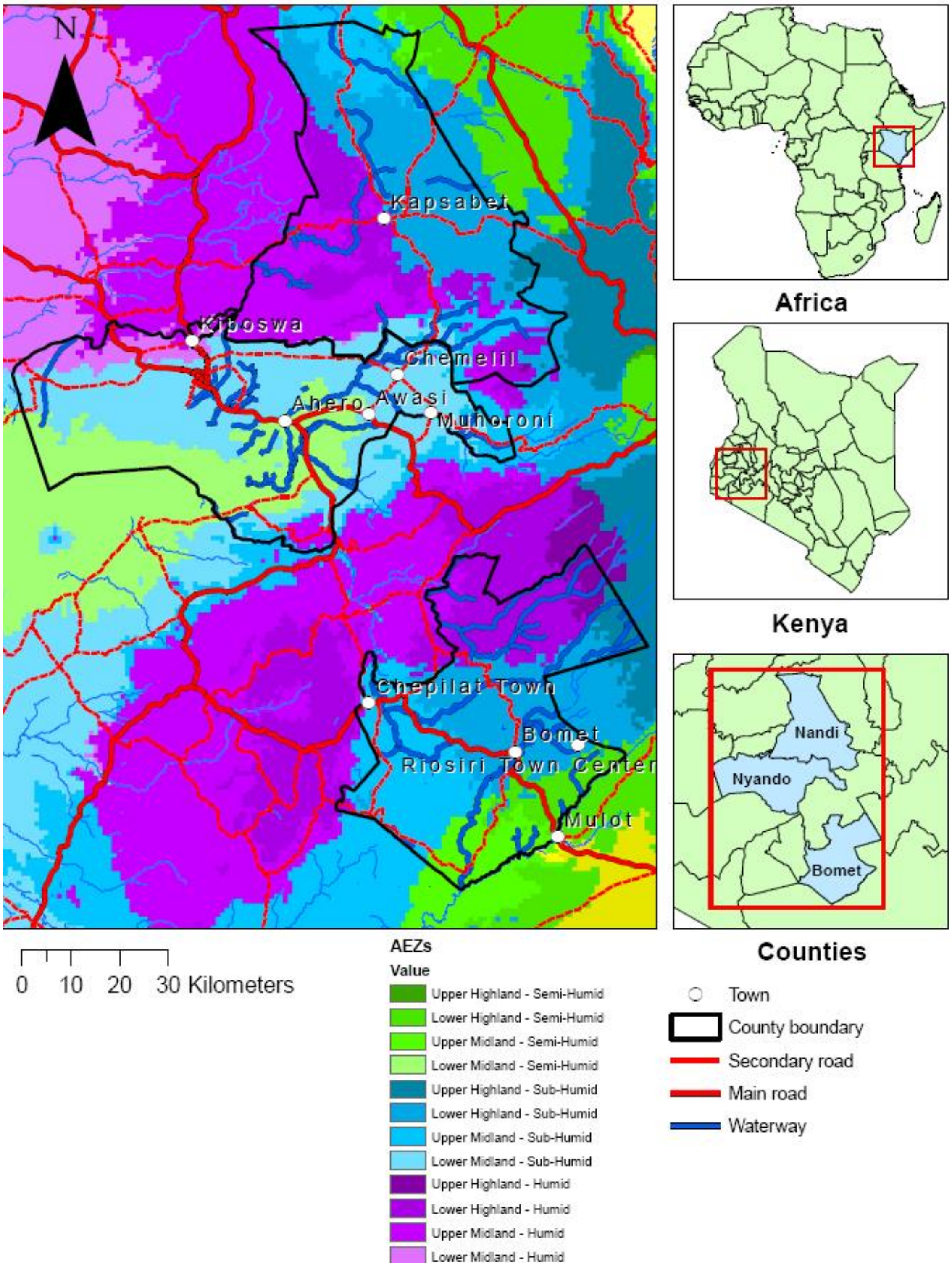


Figure 4. PCSL intervention counties in western Kenya

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. Lower Midland: mean temp 21-24 °C, 914-1219 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. Humid: 12 wet months per year, >1500 mm annual rainfall.

Agro-ecological zones modified from Karanja (2006).

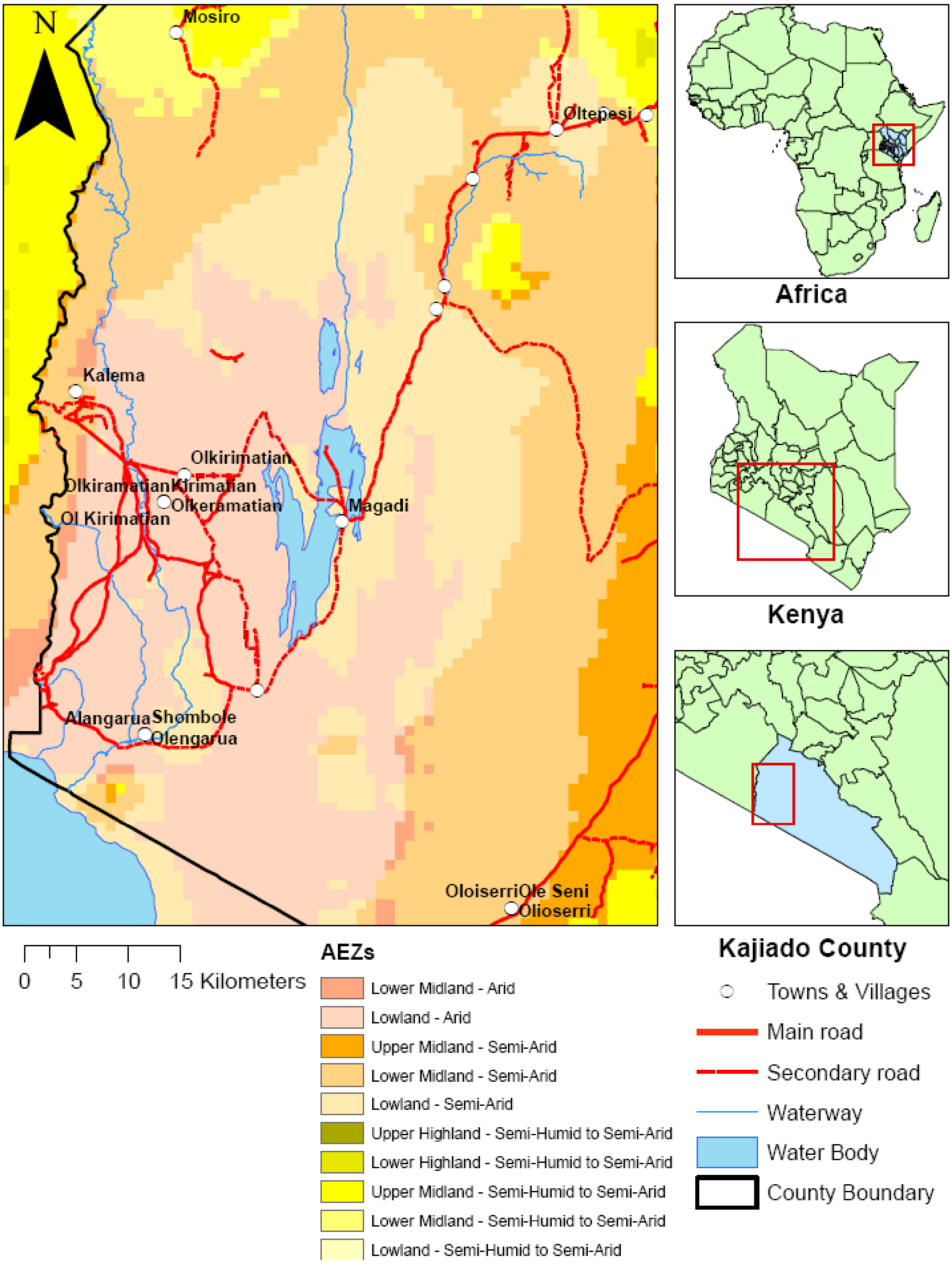


Figure 5. The PCSL intervention county in southern Kenya

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. 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).

4. Adaptation and mitigation options

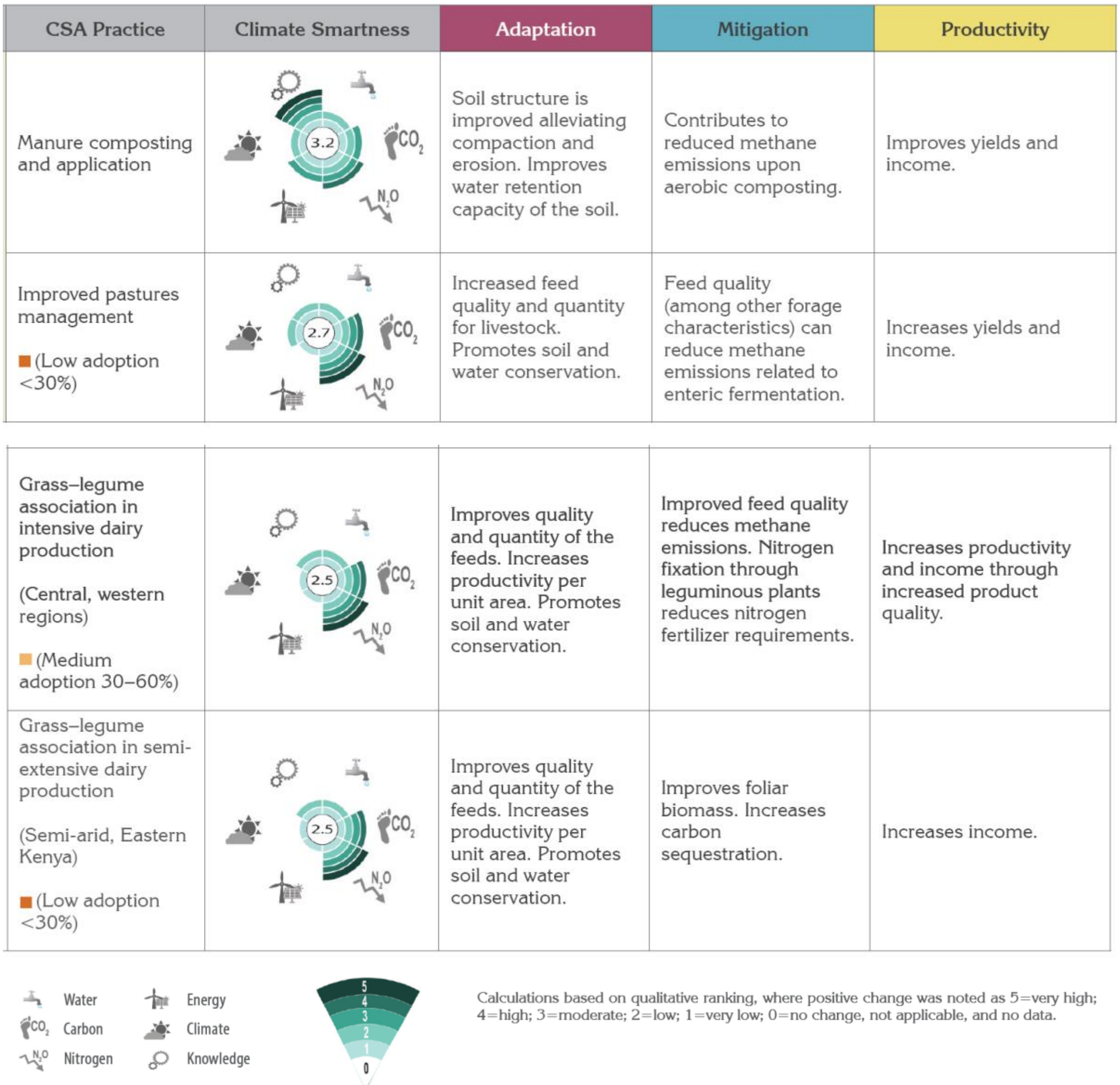
From a technical viewpoint, there is a wide range of interventions in livestock systems that can help livestock keepers adapt and become more resilient to climate change; many of these have mitigation co-benefits too. Table 5 from Bell et al. (2018) lists some of these practices, scored for their potential to address climate risks including some of those shown in Figures 2 and 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 several CSA practices with reasonable climate smartness scores according to expert evaluations, from a more extensive list developed for Kenya. The average climate smartness score is calculated based on the individual scores of each practice on six climate smartness dimensions that relate to the CSA pillars: water, energy, carbon, nitrogen, climate (mitigation) and knowledge. A practice may have a positive or zero impact on these dimensions, scored qualitatively, with 5 indicating a very high change and 0 indicating no change, not applicable or no data. The top two rows in Figure 6 describe two interventions in the agropastoral systems: manure composting and application, and improved pasture management. The bottom two rows describe the same intervention, grass-legume pastures, in two different diary systems in different areas of the country: intensive dairy production in central and western regions, and semi-extensive dairy systems in semi-arid and eastern regions (CIAT, 2017).



CSA Practice	Climate Smartness	Adaptation	Mitigation	Productivity
Manure composting and application	3.2	Soil structure is improved alleviating compaction and erosion. Improves water retention capacity of the soil.	Contributes to reduced methane emissions upon aerobic composting.	Improves yields and income.
Improved pastures management ■ (Low adoption <30%)	2.7	Increased feed quality and quantity for livestock. Promotes soil and water conservation.	Feed quality (among other forage characteristics) can reduce methane emissions related to enteric fermentation.	Increases yields and income.
Grass–legume association in intensive dairy production (Central, western regions) ■ (Medium adoption 30–60%)	2.5	Improves quality and quantity of the feeds. Increases productivity per unit area. Promotes soil and water conservation.	Improved feed quality reduces methane emissions. Nitrogen fixation through leguminous plants reduces nitrogen fertilizer requirements.	Increases productivity and income through increased product quality.
Grass–legume association in semi-extensive dairy production (Semi-arid, Eastern Kenya) ■ (Low adoption <30%)	2.5	Improves quality and quantity of the feeds. Increases productivity per unit area. Promotes soil and water conservation.	Improves foliar biomass. Increases carbon sequestration.	Increases income.

Figure 6. "Smartness" assessment for CSA practices in agropastoral (mixed crop-livestock) production systems (TOP TWO ROWS) and in intensive and semi-intensive dairy production systems (BOTTOM TWO ROWS). From CIAT (2015).

These interventions (and many others), if implemented at scale, could have considerable positive impacts on the three CSA pillars of productivity, adaptation and mitigation. Given the major transformation that Kenya is expected to undergo in the coming decades (see below), such interventions will be crucial in identifying appropriate development trajectories for the livestock sector in the future.

There is considerable scope in East African livestock systems for substantial improvements in both productivity and GHG emission intensities (Thornton and Herrero, 2014; Bell et al., 2018; ERA, 2019). For example, the dairy cattle sector in Kenya is estimated to be responsible for 12.3 million t CO_2 eq, with 48 percent coming from semi-intensive and 21 percent from intensive systems. GHG emission intensities were estimated as 2.1 and 4.1 kg CO_2 eq per kg fat-and-protein-corrected milk (FPCM) for intensive and semi-intensive systems, respectively (Ericksen and Crane, 2018). The greatest gains in both productivity and reductions in emissions intensities are in semi-intensive systems, where supplementation can reduce intensities by 24 percent and increase productivity by 32 percent (FAO & NZAGGRC, 2017). Feeding improved forages in the intensive and semi-intensive dairy and beef systems could likewise reduce emission intensities by 8-24 percent in Kenya. Climate change will have impacts on the suitability of different forage grasses in the future. Some research is being done in this area: for example, Kekae et al. (2019) showed that in some parts of the region, Buffel grass suitability is likely to be negatively affected by climate change, while Rhodes grass and Napier grass may have improved suitability under future climates. 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 and warrant further research. Improved grazing management can be suitable for extensive dryland systems and produce similar mitigation results to improving forage quality. Another option is the use of biodigesters for intensive dairy farms with 4 to 5 cows or more, which can cut total emissions from manure by 60-80 percent (Ericksen and Crane, 2018).

Targeting such interventions at broad scale remains challenging because of the variation in local agro-ecological and socio-economic contexts. For their top three interventions for reducing emission intensity in livestock products – improved forages, use of biodigestors, and improved grazing management -, Ericksen and Crane (2018) cited a range of constraints to uptake. For improved forages, these include farmers' lack of capital and land, and the unavailability of forage see of adequate quality. For biodigestors, the costs of installation, the need to transport liquid slurry and the labour required are the biggest barriers to adoption. Improved grazing management is constrained by weak governance capacities to implement appropriate grazing regimes, for example. For all three of these, a lack of know-how is a key barrier to uptake (Ericksen and Crane, 2018). In all cases, the national-to-local policy environment can be a major 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 Kenya, 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 Kenya 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).

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).

In 2010, the supply of livestock derived foods in Kenya was around 221 kcal per person per day (Table 7). This supply was 64 percent milk, 34 percent meat and 2 percent eggs, highlighting the relative importance of the dairy sub-sector in Kenya. Of the meat supply, bovine meat made up 77 percent of the 75 kcal daily per capita supply of meat, sheep and goat meat 14 percent, pork percent and poultry 3 percent. Under a model scenario of moderate economic growth and no climate change in 2050, i.e., the baseline scenario, LDF supply increases to 238 kcal in 2030 and 270 kcal in 2050. The quantity of milk supply decreases in both absolute (Kcal per person) and relative (as share of LDF supply) terms. Meanwhile, share of meat in LDF supply increases to 40 percent in 2030 and 47 percent in 2050 (up from 34 percent). Of the different meat types, the shares of beef and small ruminant meat decline while poultry and pork supplies increase in relative terms.

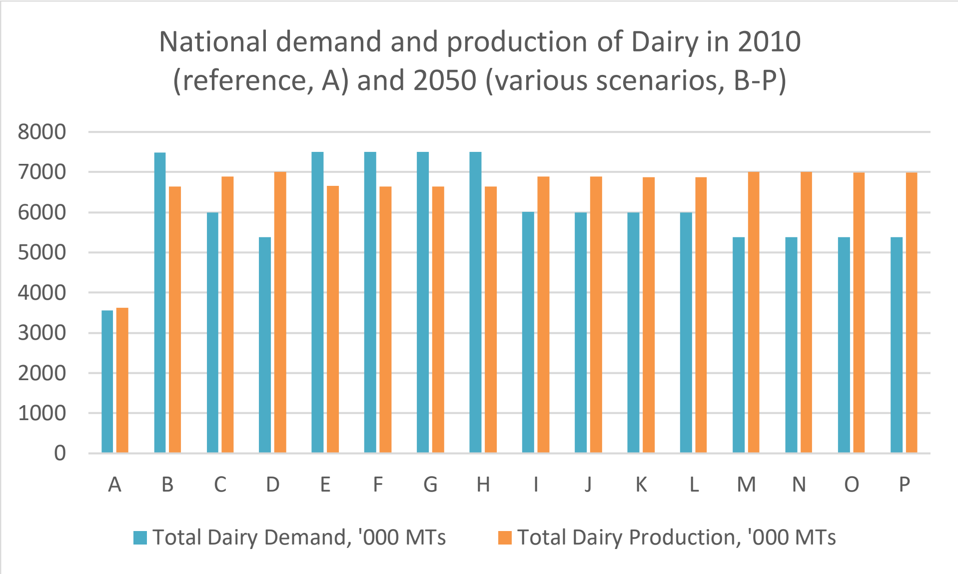
Table 7. Projections of the supply of different livestock-derived food (LDF) types in Kenya in 2010, 2030 and 2050*

	2010	2030	2050
	(kilocalories per person per day)		
Beef	57.8	71.4	90.4
Pork	4.6	6.8	10.8
Lamb	10.5	12.7	16.6
Poultry	2.2	4.1	8.0
Dairy	140.5	135.7	134.2
Eggs	5.3	7.1	10.2
All meats	75.1	94.9	125.8
All LDF	220.9	237.6	270.1

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

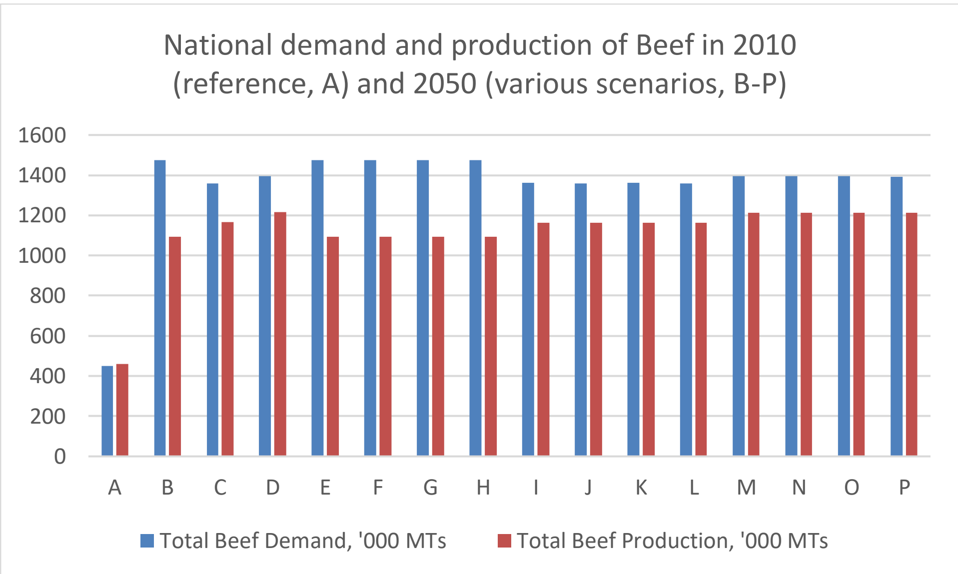
The IMPACT model projects total demand for dairy in Kenya, of 3.6 million MT in 2010. This increases to 6.8 million MT in 2050 under the baseline scenario, equivalent to a 91 percent increase from 2010. Dairy production increases by a similar margin (90 percent) over the period and Kenya remains a net exporter of dairy in both 2010 and 2050 (Columns A and C in Figure 7). Figure 7 also presents projections of Kenya's dairy demand and production for a variety of economic growth and climate change scenarios in 2050. Scenarios of moderate to high economic growth indicate a net producer position for dairy in Kenya while for low economic growth (i.e., columns B and E to H), milk demand outstrips national production, leading to a net importer position for the country in these scenarios.

Figure 7. Model projections of dairy demand and production in Kenya



The model projections of beef demand and production are presented in Figure 8. For the baseline assumption of moderate economic growth and constant climate, beef production closely matches demand in 2010, but by 2050, demand has increased 200 percent while production grows 150 percent. As a result, Kenya switches from a position of net exporter of beef in 2010 to net importer in 2050 under this scenario. This observation holds for the other scenarios of economic and climate change included in the analysis, although the low economic growth context appears to present in biggest changes in net trade outcomes.

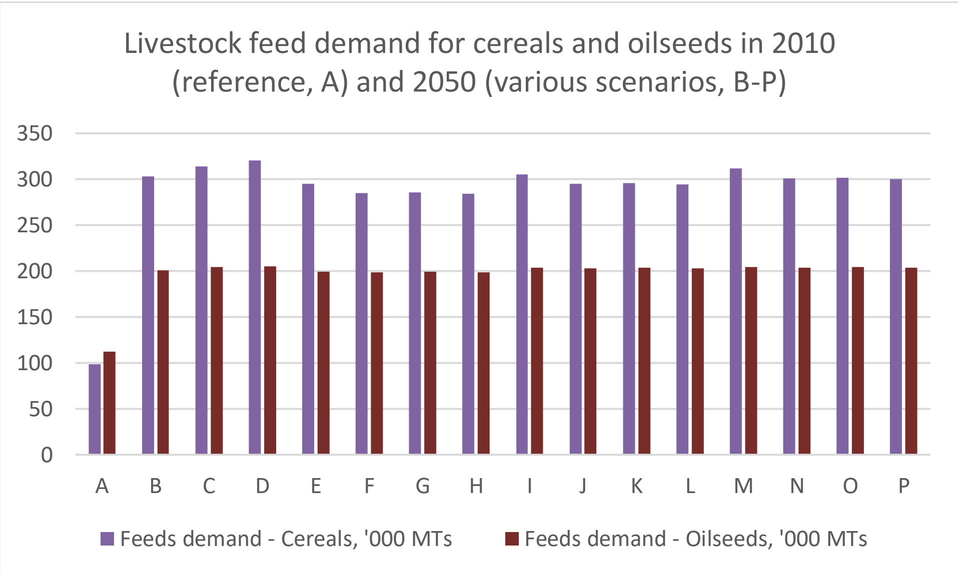
Figure 8. Model projections of beef demand and production in Kenya



Although poultry meat demand is still small in 2050, i.e., compared to that of dairy or beef, notable change is similarly projected for the poultry sub-sector. Poultry meat demand of 24,100 MT in 2010 increases to 165,800 MT in 2050 under baseline conditions of economic and climate change. Poultry meat production grows from 24,400 MT in 2010 to 83,100 MT in 2050 under the same conditions. As a result, national production declines as a percentage of the total demand, from 101 percent in 2010 to 50 percent in 2050 (not shown in figures). This observation is repeated with the other model scenarios, with production's share of poultry demand averaging 40 percent for the high (economic growth) scenarios and 56 percent in the low economic growth context.

The projected changes in the demand and production of dairy, beef, poultry, and other LDF lead to higher quantities of livestock feed demand (Figure 9). Under the baseline, the combined demand for cereals and oilseeds used as livestock feeds increases from 210,700 MT in 2010 to 518,400 MT in 2050 (i.e., 146 percent). Of the two types of feed biomass modelled, cereal demand expands by more (218 percent) than oilseed demand (146 percent).

Figure 9. Model projections of livestock feed demand in Kenya



Aggregate demand for cereals as livestock demand in 2050 ranges from 284,000 MT (under slow growth) to 321,000 MT (fast growth), while oilseed demand for the same purpose is between 483,000 MT and 526,000 MT. However, the biomass types included in the analysis, i.e., cereal and oilseeds are associated more with the raising of monogastric animals (e.g., pigs and poultry) and (minimally) with intensive ruminant livestock production. The feed types more commonly used, e.g., pastures and forages, in the more dominant of Kenya's livestock production systems, i.e., smallholder and extensive systems, were not possible to simulate using the available foresight analysis tools. The analysis as such likely under-estimates anticipated changes in feed biomass use in Kenya to 2050.

The IMPACT model results demonstrate relatively muted effects of climate change on the livestock sector at the national level for Kenya, given the assumptions made and the limitations of the modelling approach. This can be seen in Figures 7-9, 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 Kenya 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 Kenya 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.

In Kenya, demand for livestock-derived foods will be more diversified in 2050 compared with 2010.

Dairy is projected to be replaced by other LDF in the diet. Possibly these trends may be explained by demographic factors such as income growth and urbanization, but they need to be explored better through research. An understanding of what drives LDF diversification in a country will be important for assessing what changes can be anticipated in food and nutrition security, economic welfare, and environmental impacts as livestock sector-related determinants change.

The results presented above suggest that country-level solutions that effectively manage the livestock sector under one climate future will do so under others, at least with respect to factors that impact directly on LDF supply (though see the discussion above on limitations of the IMPACT analysis). Robust policies, i.e., those that will hold up under all/most of the identified possible futures may however not be so straightforward to attain. For one, the analysis has focused on country-level interactions within the livestock sub-sector, and national aggregates of indicators. Additional analyses will be needed to understand how the results will play out at more disaggregated levels. For example, to understand who the losers and winners are from increasing production gaps, what categories of livestock producers and production need to be better supported, managed or regulated, and how different livestock value chains and end consumers may possibly be affected differently by the status quo and by interventions.

6. The national livestock policy environment

Kenya has a single government ministry covering agriculture, livestock and fisheries. This Ministry is a successor to the earlier Ministries of Agriculture and Ministry of Livestock and Fishery. The current ministry is mandated with the following:

- Formulation, implementation and monitoring of agricultural legislations, regulations and policies;
- Support of agricultural research and promote technology delivery;
- Facilitation and representation of agricultural state corporations in the government;
- Development, implementation and coordination of programmes in the agricultural sector;
- Regulation and quality control of inputs, produce and products from the agricultural sector;
- Management and control of pests and diseases and;
- Collection, maintenance and management of information on the agricultural sector.

The Ministry of Agriculture, Livestock and Fisheries has defined an overarching objective to improve the livelihoods of Kenyans, ensuring food security through the creation of an enabling environment and sustainable natural resource management. The ministry implements its mandates through three state departments: (i) Agriculture, (ii) Livestock, and (iii) Fisheries, that are to be anchored to innovative, commercially-oriented approaches for building and supporting a competitive agricultural sector.

Ministry activities in the livestock sub-sector are coordinated by the State Department of Livestock. Many public and private institutions deliver services within this sub-sector. These include the Directorate of Veterinary Services (DVS), Directorate of Livestock Production (DLP), the Kenya Veterinary Board (KVB), Kenya Dairy Board (KDB), Kenya Animal Genetic Resources Centre (KAGRC), Kenya Veterinary Vaccines Production Institute (KEVEVAPI), Kenya Meat Commission, (KMC), Kenya Tsetse and Trypanosomiasis Eradication council (KENTTEC), Kenya Agricultural and Livestock Research Organization (KALRO), Veterinary Medicines Directorate (VMD) and middle level training institutes. Other public agencies are the National Drought Management

Authority (NDMA), New Kenya Cooperative Creameries (KCC) and Kenya Leather Development Council (KLDC), whose roles affect the livestock sub-sector directly.

Documented policies and strategies developed by the ministry and affiliated institutions have helped guide investment and other interventions in the livestock sub-sector. These include The National Livestock Policy of 2008, the Veterinary Policy of 2016, the National Environment Policy of 2012, the Policy for Arid and Semi-Arid areas of 2012 and the national policy on prevention and containment of Antimicrobial resistance of 2017. In addition, efforts are ongoing to integrate climate change strategies relevant to livestock, into more general climate policy. The country currently does not have a livestock sector master plan (LMP) - i.e., country-specific blueprints for livestock sector development that have been developed by countries such as Ethiopia and Tanzania, with the support of multilateral aid and international livestock research organizations - but is in discussions to develop one to provide a road map for improved animal productivity, production and value addition along the livestock value chains in Kenya.

The next subsections are from Ashley (2019).

Across Kenya's climate, livestock and agriculture, development, and land and environment policies, there is clear and consistent recognition of current and projected climate change impacts often with specific focus on the livestock sector. Drought occurrence, and to a lesser extent floods, have driven much of the climate change adaptation consideration for the livestock sector. Policy documents frequently cite observed and projected changes in drought occurrence and rainfall patterns and their impacts on livestock productivity, food security, and livelihoods. The 2008-2011 drought significantly impacted the sector and the country. That experience has informed much of the subsequent climate, livestock, and development policy. In addition to specific adaptation considerations, many livestock-oriented strategies across policy areas seek to build overall resilience in the sector.

Kenya's Climate Change Act, 2016, is the main legislation guiding Kenya's climate change response. The Act gives the legal mandate for many of the strategies put forth in the country's National Climate Change Response Strategy (NCCRS), 2010, including producing National Climate Change Action Plans (NCCAP) every five years. The Act also establishes a national Climate Change Council and Climate Change Fund. The Climate Change Framework Policy, 2016, outlines strategies to mainstream climate change consideration in institutions, planning processes, research and technology, education, and knowledge management. Planning and implementing climate change strategies receives substantial political support with the President of Kenya sitting as chair of the national Climate Change Council (FAO / UNDP, 2017). Climate change considerations are mainstreamed across the policy areas reviewed; only the Land Policy, 2009, does not explicitly consider climate change.

The current NCCAP, 2018-2022, provides the framework to deliver on Kenya's NDC and is aligned with the Sustainable Development Goals (SDGs; UN, 2015), Vision 2030, and Kenya's Big Four Agenda. NCCAP, 2018-2022, thoroughly integrates the livestock sector, particularly through its priority actions for disaster risk management (flood and drought), food and nutrition security, water and the blue economy, and forestry, wildlife, and tourism. The Plan aims to guide climate actions among national and county governments, the private sector, civil society and other actors.

Of climate policies reviewed, the CSA Strategy/Implementation Framework, 2018-2027, provides the strongest recognition of adaptation and mitigation needs in the livestock sector. The strategy was developed as a tool to implement the agricultural components of Kenya's NDC. Policy development was coordinated among the Ministry of Agriculture, Livestock and Fisheries, the Ministry of Environment and Natural Resources, and other government ministries and departments with support from the World Bank (KACCAL project), FAO, and UNDP. The strategy and implementation framework provide a holistic approach that addresses institutional coordination across government and non-government entities and consideration of strategies across the value chain.

Although contributions from the livestock sector form a substantial component of the countries GHG emissions, policy mitigation strategies are often not as strong or lacking. NCCAP, 2018-2022, explicitly states it prioritises adaptation in its policy goal: "Adaptation actions are prioritised in NCCAP 2018-2022 because of the devastating impacts of droughts and floods, and the negative effects of climate change on vulnerable groups in society … These actions are undertaken, where possible, in a way to limit greenhouse gas emissions to ensure that the country achieves its mitigation NDC." While livestock sector mitigation strategies are somewhat limited, Kenya has hosted a range of land-based carbon projects and biogas development programs that have relevance for the livestock sector (Nyangena et al., 2017). This includes the Kenya Agriculture Carbon project, the first project in Africa to issue carbon credits for sequestering carbon in soil. Additionally, CGIAR is supporting the country in developing its first agriculture sector NAMA designed to increase productivity and climate resilience while reducing emissions intensities in the dairy sector by at least 30 percent (CCAFS, 2019).

Kenya has been highly engaged in Agenda 2030. The SDGs and Africa Agenda 2063 are mainstreamed in the third Vision 2030 Medium Term Plan (MTP III, 2018-2022) and the second-generation County Integrated Development Plans. MTP III recognises climate change as a crosscutting theme and mainstreams climate action in sector plans with a focus on adaptation, including for the livestock sector. The Paris Agreement entered into force for Kenya in January 2017 and now forms part of the law of Kenya per the Constitution. Although Kenya's 2010 Constitution does not mention climate change, it provides the foundation of climate-related policy. Article 10 sets out national values and principles including sustainable development while Article

42 provides for the right to a clean and healthy environment for the benefit of present and future generations.

The 2010 Constitution has guided a new governance system that has devolved responsibility to County governments and strengthened accountability at local levels. The Constitution also requires public participation in policy making and across the policies reviewed, there are references to stakeholder consultations. The government agenda to further devolve authority and promote more equitable distribution of resources, however, faces limited budgets and governance capacity hinder advancement (USAID, 2017). In the livestock sector, land and water related conflicts continue to impact pastoralists and despite a progressive land policy, land takings for public and private sector investment continue.

Policy coherence

Kenya has the longest record of strong integration of livestock sector adaptation and mitigation strategies. The National Climate Change Response Strategy (NCCRS), 2010, fully integrates livestock sector adaptation strategies and begins to address mitigation. The later Climate Smart Agriculture Strategy/Implementation Framework, 2018-2027, and National Climate Change Action Plan, 2018-2020, provide the most robust adaptation and mitigation strategies for the livestock sector and are well-aligned with the SDGs. There is further policy coherence for livestock sector adaptation among Kenya's livestock, key development, and one land policy. These are these are the Draft National Livestock Policy, National Policy for the Sustainable Development of Northern Kenya and Other Arid Lands, 2012, Second Medium-Term Plan (MTP II) of Vision 2030, 2018-2022, and National Spatial Plan, 2015-2045. These policies, however, have little dedicated attention to livestock sector mitigation.

Ashley (2019) examined each policy area for integration of livestock sector climate change adaptation and mitigation and alignment with the SDGs 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. From this analysis, Ashley (2019) identified several opportunities for engagement with climate-livestock policy in Kenya, in relation to synergies, gaps and potential conflicts.

Strongest synergies across policies:

- Across policy areas, Kenya policy is strongly focused on adaptation in the livestock sector for intensive and extensive production systems. Policies consistently reference livestock insurance and early warning systems in particular.
- The country's National Climate Change Action Plan, 2018-2022, is likely to be a key driver of climate action and strongly integrates livestock sector adaptation and mitigation strategies.

Key gaps:

- Kenya explicitly de-emphasises climate mitigation including in the livestock sector and, while there are calls for synergy among adaptation and mitigation action, there is inadequate consideration of how to achieve adaptation and mitigation co-benefits. Further emphasis on co-benefits through the country's strong focus on CSA could help address this gap.

Potential conflicts:

- The country's lack of emphasis and detail on livestock mitigation options could lead to increased livestock sector emissions. The Draft Livestock Policy, 2019, for example, puts in place strategies to promote livestock products with consumers but does not overtly consider the likely increase in livestock emissions that would accompany sector growth. The lack of general policy focus on mitigation could put policies in conflict with the NCCAP, 2018-2022, and the CSA Strategy/Implementation Framework, 2018-2027, which aim to reduce livestock sector emissions as well as the NDC, which references the county's CSA framework under mitigation activities.

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

Kenya	Livestock Adaptation score	Livestock Mitigation score
Climate Policies		
Climate Average	2.5	2
National Climate Change Response Strategy, 2010	3	2
NDC, 2015	2	1
National Adaptation Plan, 2015-2030	3	1
National Climate Change Framework Policy, 2016	1	2
Climate Smart Agriculture Strategy/Implementation Framework, 2018-2027	3	3
National Climate Change Action Plan, 2018-2022	3	3
Livestock & Agriculture Policies		
Livestock & Agriculture Average	3	1
National Policy for the SD of Northern Kenya …, 2012	3	1
Draft National Livestock Policy, 2019	3	1
Development Policies		
Development Average	2	1
Green Economy Strategy and Implementation Plan, 2016-2030	1	1
Medium Term Plan (MTP III) 2018-2022 (Vision 2030)	3	1
Land & Environment Policies		
Land & Environment Average	1.67	0.67
National Land Policy, 2009	0	0
National Environment Policy, 2013	2	1
National Spatial Plan, 2015-2045	3	1

Scores:
3, the policy strongly aligns with SDGs related to livestock sector adaptation / mitigation, with specific activities, measures, and approaches aligned with SDGs.
2, the policy supports SDGs related to livestock sector adaptation / mitigation but has relatively fewer details and specific activities, measures, and approaches.
1, the policy supports the SDGs related to livestock sector adaptation / mitigation but lacks details and specific activities, measures, and approaches.
0, there is no evidence that the policy supports the SDGs related to livestock sector adaptation / mitigation.

7. Conclusions: system intervention points

Kenya is undergoing far-reaching demographic, socio-economic, policy and technological transformations. By 2050, population is expected to double (96 million) and nearly 50 percent of the people will be living in urban areas compared with 27 percent today. GDP per capita is projected to increase by over 140 percent by 2050. The demand for animal source foods will increase massively, and the livestock sector will likely change beyond recognition. Projections suggest that to 2050, beef production will treble, and beef and egg consumption per person will double while poultry meat consumption per person will quadruple. The growth in demand for LDF will provide major business opportunities for producers and value chain actors such as input and service suppliers, traders, processors, wholesalers and retailers, as well as benefits for consumers from affordably priced livestock products. These opportunities may be associated with major challenges that will need to be addressed. These include minimising the risks of zoonoses and re-emerging diseases, particularly in rapidly-expanding, heavily populated urban areas; the effective containment of antimicrobial resistance will be critical; and the implementation of sustainable intensification pathways for the livestock sector, for example (FAO, 2019).

There is relatively little literature on the national impacts of climate change on Kenyan 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.

Nevertheless, 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 continues to be challenging because of the variation in local agro-ecological and socio-economic contexts. Several issues can be identified. One is the availability at reasonable cost, particularly in rural communities, of good-quality inputs and seeds. Another is small farm sizes and the lack of available labour in many communities, which hamper the uptake of climate-smart practices such as farm fodder production from planted pastures or tree species (Njeru et al., 2016). Although a lack of technical knowledge on climate smart practices is a challenge for many farmers, Kenya is at the forefront of using ICTs in banking and for input supply, marketing and information exchange. The continuing digitalisation of agriculture is likely to open up enormous opportunities for transformation of the smallholder agricultural sector at scale.

With respect to the policy and enabling environment, several opportunities exist for engagement with climate-livestock policy in the country. Kenya policy is strongly focused on adaptation in the livestock sector for intensive and extensive production systems, with policies consistently referencing livestock insurance and early warning systems in particular. To date climate mitigation in the livestock sector (as in other sectors) has been de-emphasised, and although there are calls for synergies between adaptation and mitigation actions, more consideration could be given as to how to achieve adaptation and mitigation co-benefits. Further emphasis on co-benefits through the country's strong focus on CSA could help address this gap.

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