Climate Risk Profile
Embu County

Highlights

- Embu County heavily relies on the agricultural sector both as the principal source of food and nutrition and as the backbone of the economy. The great majority of the population (70%) derives their livelihood from crop production and livestock keeping. The key value chain commodities produced by the majority of farmers are maize (61-100% of the farmers), followed by dairy cattle (41-60%) and banana and beans (21-40%) which contribute to both household food and livelihood security. .

- In spite of the importance of agriculture, an estimated 20% of households are considered food insecure. Food insecurity peaks between the months of April and June, when harvested stocks have been depleted. This is mostly experienced in the hot and dry semi-arid lower zones of Mbeere North and South.

- Food insecurity is tied to a combination of factors that include climatic conditions, extreme weather and climate shocks, natural resource management, and access to appropriate inputs. Water is a constraining factor that limits productivity for both crop production and livestock rearing. Only 5% of the County is under irrigation and there is great potential to expand the irrigated area through water harvesting and storage in ponds and pans.

- Reliance on rain-fed agriculture makes farmers in Embu especially vulnerable to climate shocks and changes. Historical records indicate that that both dry spells and extreme precipitation are recurrent hazards in the County. Dry spells during the second wet season average around 65 consecutive days of moisture stress. Extreme precipitation and flood risks are quite high on average in both seasons.

- Some of the most widely used on-farm strategies include: soil and water conservation, tree planting, changing crop type and water harvesting. Female-headed households are more likely to adopt water harvesting techniques because it reduces the time spent gathering water for domestic purposes and it ensures reliability and availability of water for the household. Male-headed households are more likely to invest in longer term strategies to improve yields and ensure sustainable production through diversification in enterprises and off-farm employment. These differences may relate to differences in access to information and resources.

- In Embu County, the main sources of information for farming practices, including coping and adaptation strategies, are traditional, indigenous knowledge and radio (GoK, 2014). Traditional knowledge and radio are considered an important source of information to over 70% of the households irrespective of the gender.

- Off-farm service, such as early-warning systems, extension and training, credit, storage facilities and market information, are offered to farmers by public, private, non-profit, faith-based organizations, local and international organizations. However, the capacity to deliver relevant and timely information to farmers throughout the County is limited by coordination, infrastructure, and resource constraints. The various departments and institutions in Embu County lack proper coordination and collaboration thus leading to redundancies and duplication of roles in addressing and building resilience to climate change.

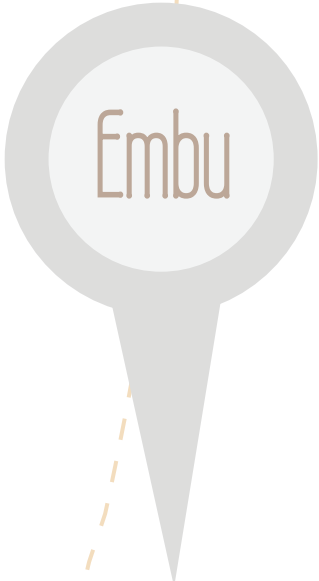
KaPP
Kenya Agricultural Productivity Programme

Republic of Kenya

WORLD BANK GROUP

List of acronyms

ACK	Anglican Church of Kenya
AEZ	Agro Ecological Zone
AFC	Agricultural Finance Cooperation
AI	Artificial Insemination
AMS	Agricultural Mechanization Services
ASDSP	Agricultural Sector Development Support Programme
BGA	Banana Growers Association
CIAT	International Center for Tropical Agriculture
DOE	Diocese of Embu
EBGCSL	Embu Banana Growers Cooperative Society
EEACS	Embu East Agribusiness Cooperative Society
FBO	Faith-based organization
GEF	Global Environmental Facility
ICIPE	International Centre of Insect Physiology and Ecology
IFAD	International Fund for Agriculture Development
IPM	Integrated pest management
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KACCAL	Kenya Adaptation to Climate Change in Arid and Semi-Arid Lands
KALRO	Kenya Agricultural and Livestock Research Organization
KAPP	Kenya Agricultural Productivity Program
KCC	Kenya Cooperative Creameries
KCEP	Kenya Cereals Enhancement Programme
KFS	Kenya Forest Service
KMD	Kenya Meteorological Department
LD	Livestock Department
MoALF	Ministry of Agriculture, Livestock and Fisheries
NCAP	National Climate Change Action Plan
NCPB	National Cereal and Produce Board
NCCRS	National Climate Change Response Strategy
NDMA	National Development Management Authority
NEMA	National Environmental Management Authority
SACCOS	Savings and Credit Cooperative Societies
SCCF	Special Climate Change Fund
VCC	Value Chain Commodity
WEMA	Water Efficient Maize for Africa
WB	World Bank



Foreword

Climate change is becoming one of the most serious challenges to Kenya's achievement of its development goals as described under Vision 2030. Kenya is already extremely susceptible to climate-related events, and projections indicate that the impacts are likely to affect the country in the future. In many areas, extremes and variability of weather are now the norm: rainfall is irregular and unpredictable; some regions experience frequent droughts during the Long Rain seasons or severe floods during the Short Rains. The arid and semi-arid areas are particularly hard hit by these extreme changes putting the lives of millions of households and their social and economic activities at risk.

In 2010, Kenya developed a National Climate Change Response Strategy (NCCRS) which recognized the importance of climate change impacts for the country's development. This was followed by the development of the National Climate Change Action Plan (NCAP) in 2012. The focus of these initiatives including the development of country climate profiles have been considered at national level. As the country shifts towards County governance and focus, there is need to mainstream climate change perspectives in programs and development plans at the County level.

In support of this effort to strengthen local capacities of stakeholders to reduce the near-, medium- and long-term vulnerability to current and future climate variability, the Kenyan Government, through the Ministry of Agriculture, Livestock and Fisheries (MoALF) is implementing the Kenya Adaptation to Climate Change in Arid and Semi-Arid Lands (KACCAL) project. The project is funded with a grant from the Global Environmental Facility (GEF)/ Special Climate Change Fund (SCCF) through the World Bank (WB). The present study is part of the KACCAL project. It aims to inform the County government and stakeholders on the climate change risks and opportunities for agriculture so that they are able to integrate these perspectives into their development plans and processes.

This document presents the Climate Risk Profile for Embu County, where climate variability has been accompanied with a significant increase in attendant risks, as repeatedly documented in national news coverage. Embu County is particularly susceptible to sustained and extreme droughts, historically causing major damage and even total crop failure to staple crops like maize and illness and even death to livestock. In the past decade, prolonged droughts have contributed to reduced crop yield, the drying up of seasonal rivers like the Thura, and seasonal variation- so much so that Mbeere sub-County now experiences just one successful season annually (GoK, 2012). To address these challenges, farmers have adopted some well documented coping strategies that include introducing climatically appropriate crop varieties, such as the Tego variety of drought-resistant maize that was distributed by KALRO researchers under the aegis of WEMA, to some 10,000 farmers through demonstrations plots . The County is also attempting to improve the dissemination of information about farming technology and markets, such as advising farmers when to store or sell their surplus based on market prices . Even more recently, a well-publicized irrigation project has successfully enabled 700 Embu families to diversify their crop production and improve cattle stocks through zero grazing, with potential to expand throughout the County . The disastrous nature of severe drought makes the identification of impending climate risks an urgent matter: likewise, considering how practices that help citizens become more resilient in the face of imminent threats to their health, safety, and livelihoods becomes an exercise with the potential to affect hundreds of thousands of lives.

The Profile is organized into six main sections, each reflecting an essential analytical step in studying current and potential adaptation options in key local agricultural value chain commodities. The text first offers an overview of the County's main value chain commodities key to food security and livelihoods, as well as major challenges to agricultural sector development in the County. In the next section, the main climate hazards are identified based on the analysis of historical climate data and climate projections, including scientific assessments of climate indicators for dry spells, flooding, and heat stress among other key hazards for agriculture. Then it continues with an analysis of the vulnerabilities and risks posed by the hazards deemed to be potentially most harmful to the respective value chains. Based on these vulnerabilities, current and potential on-farm adaptation options and off-farm services are discussed. The text also provides snapshots of the policy, institutional and governance context that can enable adoption of resilience-building strategies. Finally, it presents potential pathways for strengthening institutional capacity to address potential future climate risks.

1 As reported by Star online newspaper (Star, 2013).
2 As reported by Star online newspaper (Star, 2014).
3 As reported by Star online newspaper (Star, 2013).
4 As reported by Star online newspaper (Star, 2016).

Agricultural context

Economic relevance of farming

Embu County heavily relies on the agricultural sector both as the principal source of food and nutrition and as the backbone of the economy. The majority of the population (70%) earn their livelihoods from crop production and livestock keeping (GoK, 2013). Horticulture is a major enterprise in the region, where major cash crops include vegetables, fruits, nuts and floriculture for both local and export markets. In 2014, the County earned about 7.5 billion Kenyan shillings (KES) in income generated by crops, with horticultural crops contributing about 73% (KES 5.5 billion), maize about 9% (KES 682 million), and beans about 10% (KES 755 million). In the same time period, the major outputs from livestock included milk (KES 50 million), eggs (KES 11.9 million), and honey (KES 8.25 million) (GoK, 2014). More than 80% of the households in Embu are food secure. This is partly attributable to the high productivity levels Countywide for both crops and livestock (GoK, 2014).

On-farm activities contribute KES 55,900 per year to the average household income. Income from crop production represents the largest part of all on-farm income, followed by livestock activities. On a cash value basis at household level, crop income represented 62% of all on-farm income compared to livestock's contribution of 14% and the remaining from other sources. Female-headed households earned a fraction of income generated by on-farm activities (KES 36,779) compared with adult male households (KES 78,170) and youth-headed households (KES 55,644). Several factors likely contribute to this disparity, amongst the most important: men have more access to farm inputs and extension services; men are the primary owners of resources; and women are less involved in household decision-making. Decision-making for production activities relating to commercial crops (coffee, tea, and grafted macadamia) is dominated by adult males, possibly due to higher incomes, this further explains the disparity.

In addition to the direct production of crops and livestock for commercial sale, the majority (83%) of Embu's working labour force is involved directly or indirectly in the agricultural sector. In rural areas, the self-employed, who comprise 10.2% of the total population, are mainly engaged in cash crop farming of commodities like tea, coffee, khat ('miraa') and dairy cattle. Those in urban areas engage in small businesses as well as retail and wholesale businesses. The informal sector ('jua kali') also contributes significantly to self-employment in urban and market centres. The unemployment rate in the County increased from 12.70% in 2006 to 40% in 2011. Of this percentage, 64% are estimated to be youth. Reasons attributed to this include, high incidence of rural to urban migration that compromise the agricultural potential in the County considering that most of the agricultural activities are in the rural areas; school dropout cases; low economic growth; and lack of entrepreneurial skills among the youth. (GoK, 2013). About 11.2% of the total population employed in the County are wage earners. These include formal wage earners such as teachers, public servants, general labourers, and those employed in the production and manufacturing sector (mining, agro industry) such as mining of the sand in the rivers in Mbeere and Ishiara, building stones in Siakago, Ngaduri and Munyori.

People and livelihoods

According to the last census, the population of Embu County was estimated at 516,212 people and projected to grow to 591,415 by 2017 (GoK, 2013). The County is mainly rural, with two urban centres in Embu Town and Runyenjes Town and several major market centres in Siakago, Ishiara, Kiritiri, Karaba, Manyatta, Kianjokoma, Kibugu, Makutano, and Gachoka. The population is concentrated along the major permanent water sources (rivers and dams) in the lower zones of the County where irrigation of approximately 1 acre per household of crops such as tomatoes, watermelon, green maize, french beans and khat (muguka) farming, and fishing are common.

The settlement pattern in the County is influenced by socio-economic activities, rainfall, and soil fertility. The lower regions that are largely semi-arid, Mbeere North and Mbeere South receive less rainfall and are characterized by more scattered settlement patterns compared to the cold and wet upper regions of Runyenjes and Manyatta which receive more rainfall. The majority of rural populations are found in the areas with high agricultural potential, such as Runyenjes and Manyatta. The semi-arid lowland areas, particularly Mbeere North and South, have less agricultural potential and, accordingly, less population density. The urban population continues to grow as towns open up new settlements, especially along the Embu-Meru highway. Other major roads are experiencing similar population growth, including along the Kiritiri-Embu, Embu-Siakago-Kiritiri, and Embu-Ishiara roads. This population growth has significantly improved the economic activities in the area.

The incidence of poverty in the County is approximately 42% (GoK, 2014). Livelihood indicators are likewise stronger than the national averages, with 26.1% of the County's households having access to electricity, 85% having access to potable water, and 43.9% having access to piped water (GOK, 2013).

Agricultural activities

Agricultural potential in the County varies by agro-ecological zone (AEZ), depending on the thermal and altitudinal conditions, from the hot and dry semi-arid lower zones in the Tana River Basin in Mbeere North and South, to the windward side of Mount Kenya that is cold and wet; Embu highlands such as Runyenjes and Manyatta. The County is categorized into 8 agro ecological zones (AEZs) (GoK, 2013):

- LH1, characterized by cold and wet areas, receives high amount of rainfall (Runyenjes, Manyatta). Tea, dairy cow are common in this AEZ.
- UM1, warm and humid, includes areas such as Kieni North, Kagari, Gaturi North. Maize, bean, coffee and banana are key value chains in this AEZ.
- UM2, warm and humid, includes areas such as Runyenjes Central. Maize, beans and bananas production predominates.
- UM3, warm and humid, includes areas such as Kagari south and Githumu, where maize, beans and bananas are grown.
- UM4, warm and semi humid, includes areas such as Gachoka. The main crop produced here is maize.
- LM3, characterized by hot and dry semi-arid areas of Mbeere North and South, is known for livestock keeping and sorghum cultivation.
- LM4, also hot and dry semi-arid, including areas of Mbeere North and South, known for livestock keeping and growing of drought-resistant crops.
- LM5, also hot and dry semi-arid, including areas of Mbeere North and Mbeere South is common for drought-resistant crops such as millet, sorghum, green grams, and indigenous livestock keeping.

The main industrial crops grown are coffee, tea, macadamia and cotton, while the main food crops include maize, bean, Irish potato, sweet potato, cassava, green gram, cowpea, sorghum and millet. Drought-tolerant and drought-resistant food crops such as green gram, cowpea, sorghum and millet tend to be concentrated in the hot and dry, semi-arid AEZs in the County (LM3, LM4, and LM5), Mbeere North and South. Vegetables such as kale, cabbage and tomato are mainly produced by smallholder farmers using basic irrigation practices or rain-fed schemes. Livestock production is also a major agricultural activity in the County and includes dairy and beef cattle, poultry, sheep, goat, farmed fish and rabbit. Under the Economic Stimulus Programme, the Government supported the construction of 800 fishponds that provide fish for local sale (GoK, 2014). The main types of fish include tilapia, mud fish, and catfish, which primarily come from the hydroelectric dams, Kiambere, Gitaru, Kindaruma and Masinga. Farmers diversify their agricultural activities incorporating practices such as beekeeping.

The total area under food crops is about 63,760 hectares (Ha), while the total area under cash crops is about 18,969 Ha (GoK, 2013), together accounting for approximately 30% of the total land in Embu County[5]. The largest proportion of arable land in the County is used for agriculture, with average farms sizes ranging from 1.98 acres for small-scale farmers (in part due to continued land fragmentation) to 7.4 acres for large-scale farmers, with no recorded group or company farms in the County (GoK, 2014). In 2005-06, 59.6% of land parcels in the County had title deeds (KNBS, 2006), however updated information is missing. High population pressure in the cold and wet upper regions and the lack of land adjudication in the lower hot and dry semi-arid areas of Mbeere North and Mbeere South has made landlessness a serious problem throughout the County.

Because most farm operations are small scale, farming practices, from the initial land preparation to harvesting, are carried out using limited equipment or inputs, favouring simple hand tools and oxen drawn machines. The levels of inputs used on annual crops differ by household and between seasons and type of crop grown. The major inputs used by farmers include seeds, planting fertiliser and organic manure (GoK, 2014). Storage pesticides, herbicides, top dressing fertiliser, basal fertilisers, foliar feed, and field pesticides are also used, but to a much lesser extent. In 2005-06, only 5% of the County was under irrigation (KNBS,

5 According to the KNBS, statistical abstract 2015, the County land is equivalent to 2828km2

Livelihoods and agriculture in Embu

Demographics

1.3% Of Kenya´s population

516,212 inhabitants

97% Live in rural areas

51% 49%

Access to basic needs

42% of the population lives in **absolute poverty**

Potable water	85%
Electricity for cooking	ND
Electricity for lighting	26%
Education (youth literacy rate)	77%

Food security

20% of the population suffers from **food poverty**

ND of household **income spent on food**

ND People **undernourished**

33% Children **stunted**

7% Children **wasted**

ND: No data

Infographic based on data from the County Integrated Development Plan (GoK, 2013), the Agricultural Sector Development Support Program (GoK, 2014), and Kenya National Bureau of Statistics (KNBS, 2015)

Embu

Farming

County´s farming area 82,629

29%

70% of the population employed in agriculture production

60% of farmers have title deeds

ND% are women

Farming activities

Food crops 77%

Cash crops 23%

Of county´s agricultural land

Livestock

Cattle (heads)	150,700
Sheep (heads)	220,795
Goat (heads)	436,899

Farming inputs

Water uses

ND ND ND

Fertiliser types (% of households)

NPK

52% Organic manure

66% Planting fertiliser

39% Top dress fertiliser

Pesticide types (% of households)

20% Field pesticides

46% Storage Pesticides

10% Herbicide

2006), yet updated information is lacking. Annex 1 describes the main irrigation schemes in Embu County. The challenges that are associated to these irrigation schemes include inadequate water, poor maintenance, weak farmer production and marketing organization and abandoned/non performing irrigation schemes.

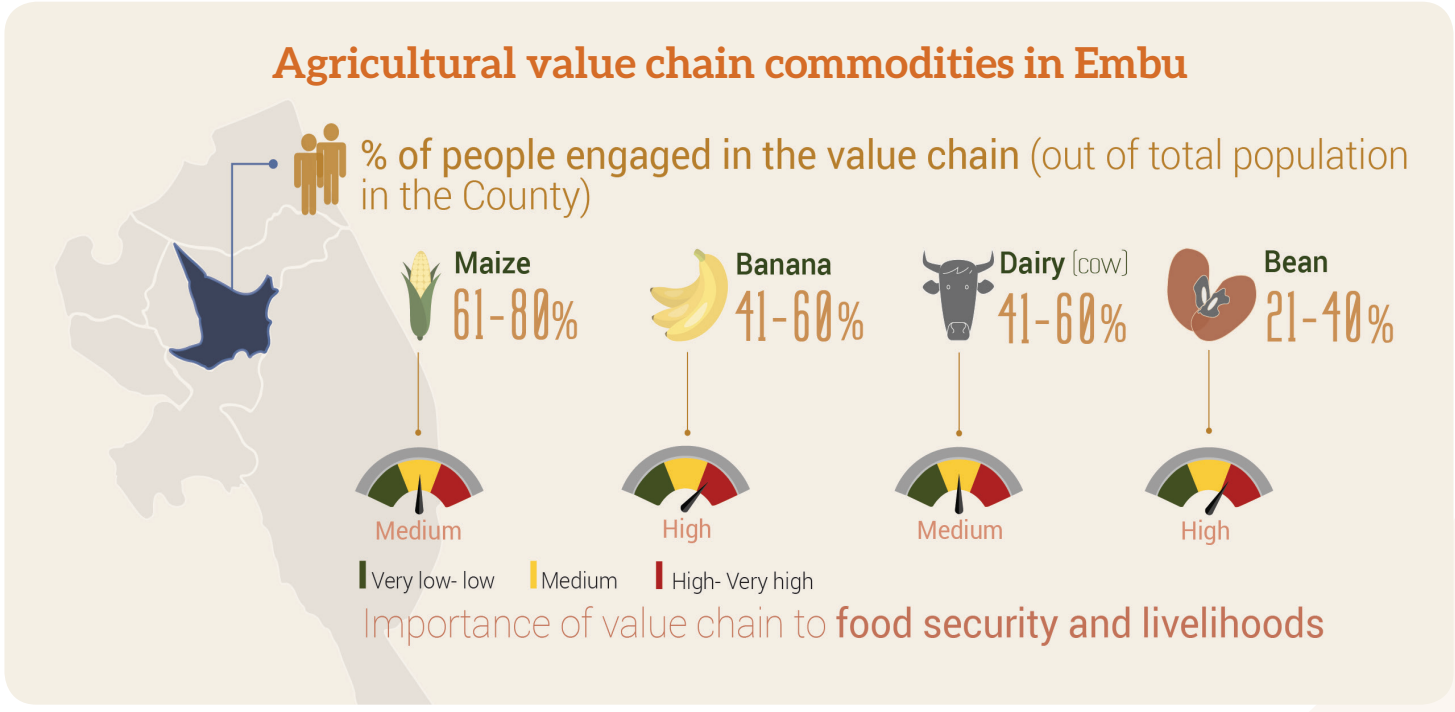
The use of inputs in livestock production is low with the exception of dewormers (70%) and minerals (52%). Adult men make most of the production decisions on the dairy cattle while women prefer making production decisions on poultry and sheep. Proportionately, more adult male-headed households use livestock inputs than either adult female- or youth-headed households. This could be attributed by the fact that adult men are more involved in livestock production than their female counterparts who prefer crop production. The major constraint to using various inputs for livestock production is the high price of the inputs, distance to markets and ineffectiveness of inputs such as AI, lack of prompt delivery of services, unavailability of these inputs.

The Agricultural Mechanization Services (AMS) facility in the Mbeere South offers tractor services for hire for land preparation, leveling, mechanized terracing, design and excavation of earth dams, and the construction of farm roads. The main source of labour on farm, whether family or hired, varies based on the gender and age of the head of household. Family labour for crop production makes up 27% of the labour on male-, 48% on female-, and 25% on youth-headed households. Alternatively, hired labour makes up 58%, 34%, and 8% of the labour used for crop production on adult male, adult female and youth-headed farms, respectively. Family labour for livestock production comprises 44% of the labour on male-headed households, compared to 34% on female-, and 21% on youth-headed households. Additionally, male-headed households are more likely (79%) to hire labour for livestock production than female-headed households (21%), while the youth do not hire labour for livestock rearing, instead prioritizing cash crop production that is considered more lucrative. (ASDSP, 2014)

Most of the households in the County use the traditional cribs and improved granary to store their cereals. This rudimentary form of post-harvest storage has led to high levels of Aflatoxin reported in the County. For this reason, some farmers have adopted improved storage technology, including hermetic bags that deplete oxygen and effectively suffocate offending insects (Baoua et al., 2012). Input stores that retail hermetic bags and other production and post-harvest inputs include NCPB stores at Majimbo in Embu Town, Ishiara market, and Siakago Town, as well as faith-based organizations, such as the Catholic Diocese Caritas of Embu, and other private service providers (GoK, 2013).

Agricultural value chain commodities

Agricultural production in Embu County is characterized by subsistence mixed farming and production of



commercial crops. Yields in the upper parts of the County that are cold and wet and in the warm and humid AEZs are generally high due to favourable rainfall, irrigation schemes (Annex 1), and access to necessary inputs. However, in the hot and dry, semi-arid low lands, where farmers depend more on rain-fed agriculture and where rainfall is less reliable, the yields are generally lower.

Various value chains have been prioritized for development interventions by different government organizations and programs, such as the Agricultural Sector Development Support Programme (ASDSP), the Kenya Agricultural and Livestock Research Organization (KALRO) and University of Nairobi survey, and the Kenya Agricultural Productivity Program (KAPP). For the development of this County Climate Risk Profile, four major value chain commodities (VCCs) were selected for in-depth analysis, based on their contribution to food security, productivity characteristics and importance to the economy. These VCCs, validated by local stakeholders, have been selected from a list compiled from the above-mentioned documents, using the following prioritization indicators: harvested area (hectares), production (90 kg bags), variation in production (in the past five years), value of production (KES/bag), dietary energy consumption (Kcal/capita/day), protein content (gr of protein/ 100 gr of product), iron content (mg of iron/100 gr of product), zinc content (mg of zinc/100 gr of product), and Vitamin A content (IU Vitamin A/100 gr of product). The VCC selected are maize, bean, dairy (cattle) and banana. Maize was selected mainly for food security, as it is a staple food in the County, bean for food security and its economic value, banana was selected uniformly for its economic, productivity and food security contributions and dairy cow was selected for economic purposes, as it is highest earner among other value chains.

Maize

Maize contributes to both food security and sustainable livelihoods in Embu County. As a staple of the population's diet, maize is often mixed with beans to make githeri or prepared as ugali accompanied by vegetables. Maize is mainly grown in the warm and humid AEZs, UM1, UM2, UM3 and UM4. These areas include Kieni North, Kagari, Gaturi North, Githimu etc. Some farmers in the hot and dry semi-arid areas of AEZs LM5, Mbeere North and South also engage in maize farming despite the low yields. They also plant early maturing varieties like Duma 41 together with farmers from the UM4 zone such as Gachoka.

In economic terms, annual maize production accounts for KES 682 million, equivalent to 9% of the County total income[6] generated from the crops (GoK, 2014). Maize requires abundant annual rainfall, between 1,200 and 2,500 mm, however rainfall in Embu is bimodal and varies with altitude, ranging from 600 to 1,800 mm. Most precipitation occurs in the two main seasons, from March to May and again from October to December, although sporadic showers also occur from July to August. Maize requires rich, well-drained, light-loam soils. The soils in the county range from sandy loams to red loams of volcanic origin to isolated pockets of black cotton soils. Overall, the soils are generally low in fertility. Soil improving inputs, especially manure and fertilisers, are thus considered important for maize production. Chemical inputs are bought from the agro shops and the National Cereals and Produce Board (NCPB[7]), while manure is readily available on farm. Other necessary inputs, such as seeds, are bought from the seed companies, agro dealers and individual farmers.

Most farm operations from land preparation to harvesting are manual or with the use of ox-drawn implements, especially in the hot and dry semi-arid lower parts of Mbeere. Post-harvest management in the maize value chain includes transportation, storing and the processing (for example, maize threshing). Actors involved include farmers, buyers, agricultural extension officers, input and service providers, in particular, the Caritas of Embu. The prices of maize are determined entirely by market forces, as there are no cooperatives active in this value chain in the County. Activities typically organized by cooperatives, such as bulking, bargaining, accessing trade facilities, and setting prices, are not available in any systematic way.

The major challenges associated with the maize value chain include marketing and distribution characterized with the non-existence of the cooperatives, pests and diseases such as stalk borers, squirrels and the storage pests such as large grain borer. Another key challenge is represented by extreme weather conditions mostly felt in the hot and dry semi-arid lower zones of Mbeere North and South, where rainfall is largely unreliable.

Bean

Beans also contribute to food security and household income in the County. The staple food githeri is a mix of beans and maize and an important part of local diets. Beans contributed to 10% (equivalent to KES 755 million) of the County's total income generated

6 Total income generated from food crops was KES 7.5 billion.
7 NCPB provide the inputs at subsidized price.

from the crops in 2014 (GoK, 2014). Beans grow well within a range of temperatures from 17.5 to 27o C, while in Embu County, average temperatures range from 12o to 30o C (GoK, 2013). Beans in the County are mostly intercropped with maize thus will be found in the same agro ecological zones mentioned above. Beans require a moderate, well-distributed rainfall (900 to 1,200 mm) per annum, however dry weather during harvest is very important. Suitable soil type for bean production range from light to moderately heavy, with considerable organic matter. This is not quite the scenario in Embu County, where the soils are generally low in fertility (as described above) and require fertilisers and soil improving inputs. Likewise, chemical inputs are commonly used to control pests and diseases, such as aphids, bean rust, and bean fly. These agro chemicals can be acquired from the stockists in the market centres in Siakago, Ishiara, Kiritiri, Karaba, Manyatta, Kianjokoma, Kibugu, Makutano and Gachoka. Seeds are also generally acquired from stockers. KALRO also sells certified seeds in Embu. These good quality seeds are considered to contribute to increased bean production.

Farm labour includes both family and hired labour. On-farm production involves land preparation for pest management and weed clearance; planting for propagation; weeding to eliminate the competition of the nutrients and the control of pests; and harvesting. The post-harvest stage of the value chain involves sorting (to remove the broken or damaged beans) to ensure quality; winnowing to clean the produce and prepare for dusting; and storage using the hermetic bags.

As in the maize value chain, there are no cooperatives in the bean value chain and prices are set in the local and major market centres. The promotion of the beans is done at the market centres and through the radio in wimwaro, where information regarding the comparative prices of different areas is made available to farmers to help them decide where, and for how much, to sell.

The main decision-makers for bean production are women, as the cultivation of beans is less labour-intensive and the crop is harvested earlier. Most of the women use less inputs than men due to high input prices, the distance to market and the inadequate availability of inputs in the County. Women also use less inputs in the bean value chain as the crop thrives well without external inputs.

The major challenges associated with this value chain include pests and diseases mentioned above and the lack of farmer cooperatives, which contributes to exploitation by middlemen.

Banana

The banana value chain is important for food security and the economic prosperity in Embu County. Bananas are perennial tropical plants whose fruits are used as a staple food both for cooking (plantains) and as table fruits for direct consumption. Bananas grow well in fairly hot and humid areas that are within an altitude of 0 to 1,800 meters above sea level (with the exception of "Dwarf Cavendish" which can grow well up to 2,100 meters above sea level). Thus, bananas in the County are mainly cultivated in the AEZs UM1, UM2, UM3 and it extends to the cold and wet agro ecological zone LH1. Annual precipitation of at least 1,000 mm per year is necessary, but in order to achieve good yields bananas should consistently receive 200 to 220 mm water per month (Biovision, 2016). The County's bi-modal rainfall pattern is thus less than ideal for banana production. Likewise, average temperatures in Embu County (again, 12°C to 30°C) dip below the 27° to 38°C considered ideal for banana production. The best soil for bananas is a deep, friable loam with good drainage and aeration characterized by high fertility and organic matter content of 3% or more. For these reasons, Embu farmers typically apply manure and sometimes other inputs to increase soil fertility. High-quality planting materials are often acquired from the Jomo Kenyatta University of Agriculture and Technology (JKUAT) satellite nurseries, individual or private nurseries, and KALRO nurseries.

On-farm production often engages extension officers that help with farm layout, while family and hired labour is used for maintenance, including weeding to combat nutrient competition and control pests and diseases such as mites, aphids, banana nematodes, banana weevils and fungal diseases such as yellow sigatoka leaf spot[8]. Post-harvest production includes collection and bulking, where the bananas are aggregated to a central collection centre and transported to the buyer or market. Value-adding processes include sorting and grading bananas by quality and the production of wine, flour, and crisps or chips for local shops and supermarkets.

There are two banana cooperatives in the County: Embu Banana Growers Cooperative Society (EBGCSL) Limited and Embu East Agribusiness Cooperative Society (EEACS). The Banana Growers Association (BGA) of Kenya, which was formed for banana growers nationwide but has since been disaggregated to the County level, sometimes lobbies for the needs of their banana farmers members. EBGCSL has 48 groups with 1,600 registered members. These associations, cooperatives, and farmer groups are engaged in product promotion, pricing, and market

8 Commonly known to the farmers as *sigatoka*

access. Groups take an active role in organizing the buyers and informing the farmers of the buyers' needs and conditions. The International Centre of Insect Physiology and Ecology (ICIPE) and Technoserve are also involved in linking the banana farmers to the market.

The major challenge associated with this value chain include the control of pests and the diseases. Most farmers are constrained to purchase pesticides due to high costs.

Dairy (cow)

Rearing livestock is a major agricultural activity in Embu County, with commercial production concentrated in the cold and wet AEZ LH1 of the County such as Runjenyes, Manyatta whose breeds include Friesian and Ayrshire while in the LM3, LM4 and LM5 hot and dry semi-arid lower zones of Mbeere North and South, indigenous breeds such as Zebu and cross-breeds are popular. The main inputs in this value chain include housing, feeds, dewormer treatments and vaccinations. The key providers of these and their related services include farmers, agro vets, veterinary departments, and extension officers. These inputs are important for maintaining the cows' health and increasing productivity. Breeding services are carried out by both public and private veterinary service providers. The Livestock Department (LD) is involved in providing extension services; however their effectiveness is limited by a lack of personnel: the ratio of extension officer to farmer in the County is 1:2,000; a far cry from the state-recommended 1:400 ratio.

The post-harvest stage of the value chain includes collection, bulking, and transportation by the cooperative societies, such as the Kenya Cooperative Creameries (KCC). Processing, such as pasteurization and packaging to improve shelf life and the production of dairy products such as yoghurt, occurs at the various private milk processing firms, including KCC, Brookside, Aspen, and Superior Highland.

Agricultural sector challenges

Embu County has the potential to feed itself and export surplus to neighbouring counties. However the County faces some serious challenges in the agricultural sector that limit productivity. As much as 80% of the population is food secure, the remaining 20% of the population faces perennial food shortages and insecurity due to low productivity. This is mostly felt in the hot and dry semi-arid lower zones of the Tana River Basin, Mbeere North and South which have unreliable rainfall patterns. The cold and wet AEZ (LH1) of the County such as Manyatta and Runyenjes and the warm and humid AEZs (UM1, UM2, UM3 and UM4) also face some challenges that deter them from reaching their potential.

High cost of farm inputs, inadequate access of these farm inputs such as improved genetic material for crops and livestock, pest and vector control, contribute to poor quality and low volume of production. Due to the limited availability and prohibitive cost of high quality plant material, livestock breeds and husbandry services, crop and livestock farmers have resorted to using low quality seeds and non-certified planting material.

In addition, the County is faced with numerous crop and livestock pest and diseases, such as fruit fly, stalk borer and large grain borer. For livestock, there are cases of Pneumonia, footrot, malnutrition and fowl pox. Most farmers plant crop varieties that are not certified and not resistant to diseases and rarely use pesticides or vector control, as the prices are prohibitive and they have limited access to research and information. The cold and wet upper parts of the County have well stocked agro shops compared to the semi-arid low areas thus farmers in the lower areas are more adversely affected than the farmers in the upper parts of the County.

The agricultural extension officer to farmer ratio in the LD is at 1:2,000, while for crop production, the ratio is 1:660; both are lower than the state-recommended ratio. Lack of adequate artificial insemination services, following the privatization of insemination and vector management services, have led to the deterioration of the quality of dairy cattle. Most of the farmers are not in a position to afford these services following their privatization as the prices are prohibitive.

There are few market centres in the entire County and most of the goods traded in these markets are food produce and livestock (with limited processing). The general lack of market information and skills amongst farmers and the business community has hampered the expansion of markets for products from the County. Weak and inadequate farmer groups and cooperatives coupled with the poor road condition in the County are the major hindrances to the marketing process. Poor organization of farmer groups has exposed farmers to exploitation by middlemen during harvest and post-harvest. Low prices for farm produce contribute to low household incomes of farmers who represent the vast majority of the population in the County. This explains why off-farm activities to generate income

are frequent. High cases of rural-urban migration are reported where mostly youth and men have migrated to the urban areas burdening the women who are left behind to engage in the agricultural activities. The men and youth have used this as an adaptation strategy to climate shocks.

Diversification of agricultural productions such as switching to high-value crops is limited in the County because of lack of knowledge of farmers, limited resources and low uptake of technologies. Farmers limited skills and training can be attributed to the scarcity of adequate agricultural extension personnel. Farmers often use inadequate agronomic practices and unsustainable natural resources such as land fragmentation and deforestation which leads to environment degradation consequently limiting the County's agricultural potential.

Climate change-related risks and vulnerabilities

Climate change and variability: historic and future trends

Embu County has a range of climates within the County ranging from wet and cool (>1250 mm annual precipitation and <17°C) in the northern portions that traverse up Mount Kenya to relatively warm and dry in the central and southern parts of the County (<1000 mm annual precipitation and >21°C). Due to this strong gradient in climate throughout the County, flooding, dry spells, and heat stress, are all hazards that contribute to agricultural risk in the County.

Historic analysis of weather in Embu County shows that both dry spells and extreme precipitation are hazards in the County. Dry spells are longer during the second wet season averaging around 65 consecutive days of moisture stress, but ranging between 60 and 80 in any given year. The first wet season only experienced about 45 consecutive days of moisture stress (ranging from 25 to 70 in any given year). Extreme precipitation and flood risks[9] are quite high on average in both seasons. The first season consistently experienced high single day precipitation, with 80% of years experiencing greater than 20 mm of precipitation in a single day. However the second wet season was more highly variable from year to year, and had three years with very high precipitation events greater than 50 mm in a single day.

Climate has already been observed to change in the County. Since 1981, the first wet season has experienced a moderate (1°C) increase in mean temperature and associated reduction in crop cycle, and a mild tendency for decreasing precipitation. The second wet season experienced no detectable change in temperature or precipitation.

Looking to the future in the years of 2021-2065, both extreme precipitation and prolonged moisture stress are projected to occur, but the changes are quite different during different seasons. Within 30 years (by the early 2040's) temperature is projected to increase by 0.4°C, with the first wet season projected to experience even greater changes. And by this time, precipitation is projected to decrease by 0.7% in the first wet season, and increase by 19% in the second wet season. Consecutive days of moisture stress is projected to substantially increase in the first wet season from approximately 45 days to over 75-80 days (more than 50% increase), depending on the greenhouse gas emissions. However, moisture stress is projected to decrease in the second wet season, with the number of consecutive moisture stressed days greatly decreasing from more than 60 days to less than 20 days. Extreme precipitation and associated flood hazards are projected to remain approximately unchanged during the first wet season, but increase by 35-60% in the second wet season, depending on the level of greenhouse gas emissions (greater emissions resulting in greater change). These projections of future climate change under the two climate scenarios—RCP 2.6 and RCP 8.5[10]—show some differences, but generally show the same trends in future projections. In general, the greater the greenhouse gas emissions, the greater the increase in moisture stress during the first season and increase in intense precipitation during the second season.

Climate Perceptions by the farmers

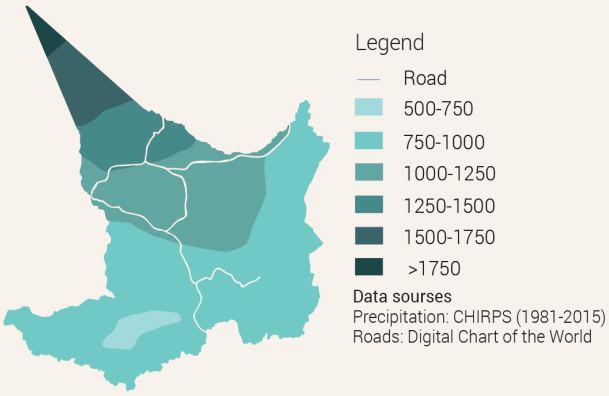
Farmers in Embu County testify to the intensive changes to climate and weather patterns in the County over time. These include increased temperatures (heat stress) in the months of January - March and August - October mostly in the hot and dry semi-arid lowland areas (AEZs LM3, LM4 and LM5 - Mbeere North and South). In the cold season, the temperatures are extremely low especially in the cold and wet AEZ LH1. Reduced rainfall is evident in the County and is mostly revealed in the hot and dry semi-arid lower zones of Tana River Basin. Floods are also experienced in these

9 Refers to the wettest 1-day event (mm/day) indicator in the infographic.

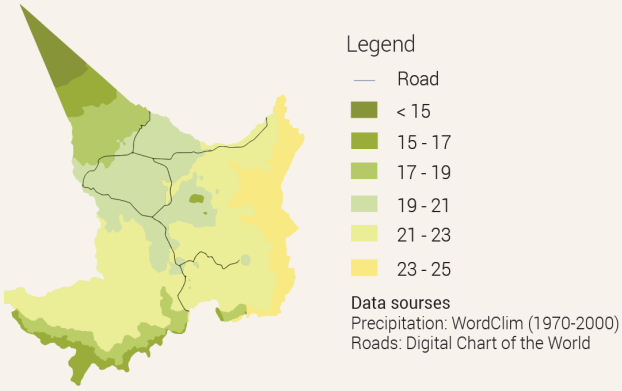
10 *The two RCPs, RCP2.6 and RCP8.5, are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6 and +8.5 W/m2, respectively). The pathways are used for climate modelling and research. They describe two possible climate futures, considered possible depending on how much greenhouse gases are emitted in the years to come. RCP 2.6 assumes that global annual GHG emissions (measured in CO2-equivalents) peak between 2010 and 2020, with emissions declining substantially thereafter. In RCP 8.5, emissions continue to rise throughout the 21st century.*

Past and future impacts of climate hazards in Embu

Historical annual mean precipitation (mm/year)



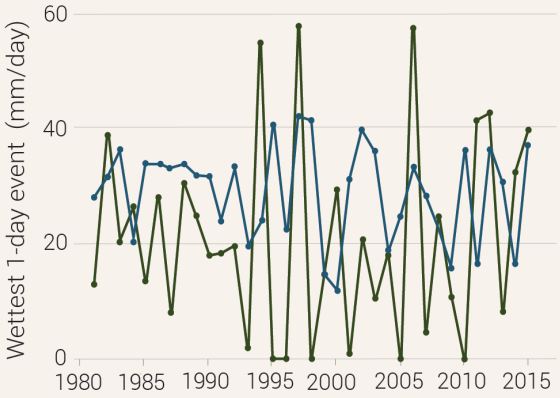
Historical annual mean temperature (°C)



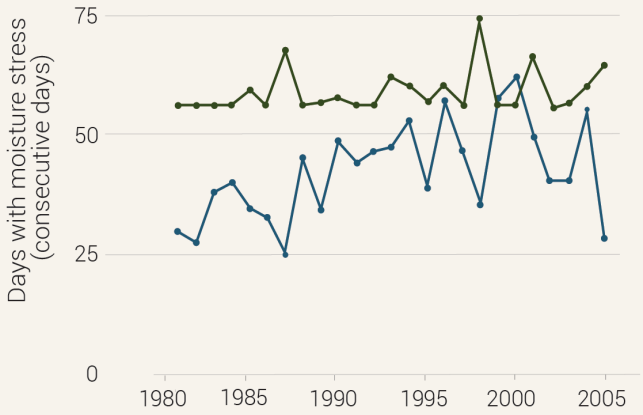
Flood hazards

Drought hazards

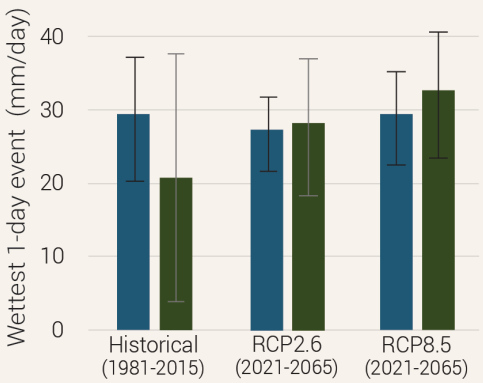
Historical extreme flood events



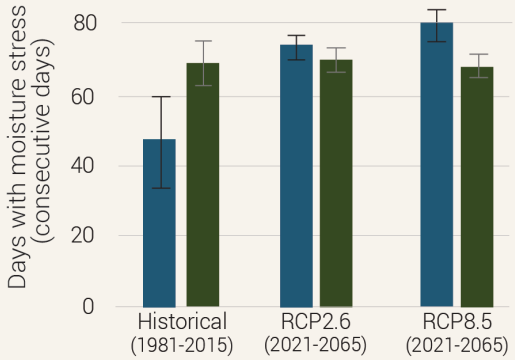
Historical drought stress events



Historical and expected extreme flood events



Historical and expected drought stress events



January - June July - December

lowlands leading to soil erosion and siltation to River Tana.

Landslides are also experienced in the tea zone area, AEZ LH1 (Manyatta and Embu East sub Counties). Informal sector/slums are susceptible to landslides due to poor planning of the housing and settlement.

According to farmers' testimonials in the focus group discussions and the workshops, there have been evident cases of loss of biodiversity, mostly of indigenous trees. They attest to the reduced water volumes, drying up of the wells and rivers mostly in the hot and dry semi-arid lower zones of Mbeere North and South.

They concluded that there are increased incidences of crop and livestock pests and diseases that seriously affect their produce thus increasing their vulnerability to food insecurity. Some of the pests and diseases mentioned include inter alia: fruit fly, stalk borers and armyworms, perceived to have increased due to climate change.

Climate vulnerabilities across agriculture value chain commodities

Climate change has already had an impact on agricultural production systems and food security as a result of the increased frequency of extreme weather events and the unpredictability of weather patterns. In Kenya, excessive rains and flooding, shifting patterns of rain and droughts, and warmer overall temperatures are amongst some of the most significant effects (FAO, 2013). Embu County is no exception: increased temperatures, heat stress, moisture stress, dry spells, and excessive rainfall increasingly compromise the agricultural activities in the County. These particular climate hazards affect Embu's key value chains in different ways, as discussed at length in the remainder of this section.

Maize

Maize production in Embu is almost entirely dependent on rainfall, and is thus highly susceptible to climate shocks. Drought, heat stress, and increased temperatures are major limiting factors for maize growth and productivity. The hot and dry semi-arid low lying areas (LM3, LM4 and LM5) of Mbeere North and South already receive insufficient rainfall, and during drought periods, the loss of soil moisture makes it difficult to till the land. Maize is sensitive to soil acidity due to the loss of nitrogen content and pests and diseases such as stalk borers, which are exacerbated during drought periods. Squirrels are a threat during the dry season because they eat the seeds. Addressing these threats commonly includes the use of pesticides or chemicals, which most of rural farmers in Embu County cannot afford.

Further, during times of drought, there are incidences of weed infestation, such as grass, that leads to the competition for soil nutrients and limits production, which in turn leads to demand spikes and high prices for buyers. Farmers with greater resources use storage pesticides to preserve their production from storage pests such as large grain borer commonly known to the locals as osama. However, poor farmers do not have access to such inputs.

Increased temperatures also pose a huge risk for maize farmers, as they increase the incidence of pests and the acidity of the soil. Wealthier farmers are able to afford and have access to the necessary pesticides, especially in the cold and wet upper zones such as Runyenjes and Manyatta, where agro-input shops are well stocked but poor farmers cannot afford expensive inputs. Higher temperatures also provide a conducive environment for weeds. Controlling the higher incidence of pest and weeds requires more labour.

Maize tolerates hot and dry atmospheric conditions so long as sufficient water is available to the plant and the temperatures are below 45°C. Increased temperatures leads to low seed viability, farm yard manure that is an important input supply, losses soil moisture making it susceptible to be carried away by the wind. Increased temperatures poses difficulty in storage, especially in the hot and dry semi-arid low lying areas of Mbeere North and South. This is attributed to the storage pesticides that thrive well with increased temperatures.

Bean

Both drought and moisture stress are limiting factors for the growth of beans. Beans require moderate, well distributed rainfall and, although dry weather is important during harvest, prolonged dry conditions are harmful to productivity. The County's hot and dry semi-arid lowlands of Mbeere North and South are thus more vulnerable to drought hazards that result in poor quality and insufficient production, and high seed costs. High prevalence of weeds suppress the beans production. This results in reduced or no sorting and winnowing of the beans, affecting negatively the distribution and the marketing spectrum.
Beans are also sensitive to moisture stress and

abundant rainfall, leading to additional labour requirements and specific storage conditions that resource-constrained farmers, and especially women, have less access to (Beehive Kenya, 2016). Moisture stress leads to wilting and deformation leading to reduced yields consequently affecting the processing of the seeds. This affects the market dynamics and this is made worse with the lack of operational and functional cooperative in this value chain.

Banana

Moisture stress can kill off banana seedlings and result in fungal diseases such as yellow sigatoka leaf spot (*Mycosphaerella musicola*) and banana nematodes and weevils tied to the reduced soil moisture content. Nurseries located in the cold and wet upper zone such as Runyenjes and Manyatta are more likely to be affected by fungus, while those in the hot and dry semi-arid lower zones of Mbeere North and South are more likely to be affected by nematodes. Moisture stress leads to yellowing and drying of leaves, reduced production tonnage, weak and falling pseudo stem. Farmers in the lowlands, especially those without irrigation infrastructure are susceptible to reduced productivity and reduced marketable tonnage. This will also affect processing activities of banana in the value chain such as banana crisps, wine.

Heat risk may lead to reduced soil fertility, due to the slow decomposition of organic matter. The hot and dry semi-arid lower AEZs are more susceptible than the cold and wet highlands. However, farmers with elaborate irrigation systems are less likely to be affected. Increased temperatures leads to infestation by sucking insects such as mites and aphids. Farmers without processing equipment, especially those in the hotter lowlands, are susceptible to these climate risks.

Dairy (Cow)

Drought is a limiting factor in the dairy cow value chain, as it puts stress on cattle feed and water provision. Fodder production is compromised, forcing farmers to seek alternative feed sources or reduce cattle's dietary intake. This leads to malnutrition and to the incidence of foot and mouth diseases. Farmers in the hot and dry semi-arid lower zones (LM3, LM4 and LM5) are more susceptible to these risks, due to the lower access to water-harvesting techniques. The cost of the feeds increases due to the scarcity of the feed which leads to high demand and low supply. Women are more susceptible to these hazards in so far as culture dictates that women and children are responsible for fetching water for the cattle. At the same time, post-harvest storage becomes more complicated under high temperatures; this exacerbates milk losses and reduces processing volumes.

Increased precipitation has negative consequences as well, especially in the cold and wet uplands such as Runyenjes and Manyatta in terms of availability of feeds due to soil erosion that destroys feeding sources, increased incidences of diseases such as pneumonia and foot rot and additional labour required to deal with these problems. Areas with better road infrastructure are less likely to be affected as there is less disruption of access to input markets and transportation of milk to markets. The cooperatives (Mkulima bora, Lugendo Alliance, Gakungu) and the private processors (KCC, Brookside, etc.) have inadequate absorption capacity and are unable to provide a guaranteed market to farmers, undermining farmers' bargaining power and price control.

Adaptation to climate change and variability

Farmers in Embu County have come up with a number of on- and off-farm adaptation strategies to cope with climate hazards that affect agricultural production and food security. Annex 4 identifies patterns of adoption disaggregated by head of household, as well as the common input requirements and challenges to implementation. Female-headed households are more likely to adopt water harvesting techniques and soil and water conservation strategies to ensure reliability and availability of water for households. Male-headed households are more likely to invest in longer term strategies to improve yields and ensure sustainable production through diversification in enterprises and off-farm employment. These differences may relate to differences in access to information and resources.

In Embu County, the main sources of information for farming practices, including coping and adaptation strategies, are traditional, indigenous knowledge and radio (GoK, 2014). Traditional knowledge and radio are considered an important source of information to over 70% of the households irrespective of the gender. This is attributed to the fact that the sources of information are cheap and readily available and the majority of the population have access to them. Information may also be transmitted through less common sources such as television, faith-based organizations such as Caritas of Embu, Anglican Church of Kenya, and other partners.

On-farm adaptation practices

Soil and water conservation is an important adaptation strategy in the County, especially in the hot and dry semi-arid areas (LM3, LM4 and LM5) of Mbeere North and South. It is also practiced in the cold and wet upper parts of the County such as Runyenjes and Manyatta and the warm and humid AEZs (UM1, UM2, UM3 and UM4). This adaptation strategy is more popular among female-headed households (50%) compared to the male- and youth -headed households (47% and 30% respectively). This can be attributed to the fact that water conservation saves women from the tedious task of fetching water. Conservation agriculture (cover cropping, minimum tillage, crop rotation techniques), planting of Napier grass, mulching, planting of fodder trees are some of the main soil and water conservation methods carried out by farmers in Embu. However, their knowledge of implementing these techniques is limited and labour costs are quite high, impeding the wider adoption of these practices.

Water harvesting is also practiced in Embu County, by 41% of the female-headed household and 34% of the male- and youth- headed household alike. Water harvesting is most common in the hot and dry semi-arid areas of Mbeere North and Mbeere South. However, not all farmers can afford to make the necessary investments required for water harvesting such as the construction of water pans, shallow wells, and water tanks.

Tree planting and agroforestry practices are also common in the County. Around 52%, 62%, 40% of the male-, female- and youth-headed households respectively engage in tree planting and planting of fodder trees. The women associate more importance to this strategy compared to the male- and youth-headed households. This can be attributed to their awareness and knowledge on the benefits of the trees as it is linked to availability of water. Trees reduce wind speeds thus protecting crops including fodder, water sources and soils. The National Environmental Management Authority (NEMA), The Kenya Forestry Service (KFS), Caritas Embu, Tea companies and Kenya Red Cross Society (KRCS) are actively involved in ensuring that the County increases its vegetative cover, however, the challenge is the lack of community participation in carrying out this adaptation strategy. Creating greater awareness within communities about the benefits of tree planting will be necessary to ensure wider adoption of this adaptation strategy.

Farmers also opt for change in crop varieties and livestock types as a response to climate shocks such as increased temperatures. Because of water scarcity, farmers in the hot and dry semi-arid areas of Mbeere North and Mbeere South and part of the warm and semi humid AEZ UM4, in Gachoka, are now planting early-maturing varieties such as Duma 41, a hybrid maize variety suitable for mid- to low-altitudes and drought-resistant crops such as pigeon pea, millet, green gram, and sorghum. A major impediment to using this strategy is poor access to improved seeds, given high prices especially for the early maturing varieties. For the livestock sector, the improved local breeds and artificial insemination are expensive,

Value addition is not widely used by farmers in Embu County. The percentage of male-, female- and youth-headed households that engage in value addition is low, 18%, 15% and 10% respectively. Value addition increases the shelf life of the products and the competitive advantage in the market because processed products catch higher prices compared to raw products. Farmers incorporate traditional knowledge in value addition, including grading and/or packaging for most of the crops (especially for vegetables and root crops), ripening, chips, and milling in the case of grains, roots and tubers and nuts. In livestock production, value addition involves boiling of milk, pasteurization and packaging of milk, and yoghurts. Other value added products include banana crisps sold in the supermarkets, banana wine and honey. The challenge of this adaption strategy is the exploitation by middlemen. Farmers also need to be better equipped with the necessary skills through education and training to ensure wider adoption of this adaptation strategy.

Off-farm adaptation practices

Off-farm services, such as early-warning systems, insurance schemes, extension and training, credit, storage facilities, and market information, are offered to farmers to increase their climate adaptive capacity. Such services are offered by a variety of actors, including: local government entities, such as the meteorological, veterinary, agriculture, and livestock departments; faith-based organizations (FBOs) like Catholic Caritas, Diocese of Embu and the Anglican Church of Kenya; state programs in places like the Upper Tana; private sector financial institutions including insurance companies and banks; and international organizations, such as Care Kenya.

Many of the off-farm services offered in Embu County are organized through participatory scenario planning meetings facilitated by the ASDSP and supported by Care Kenya. These meetings are organized every season and bring together key stakeholders under the guidance of professional experts who assist in collectively finding ways to interpret the information (both local and scientific knowledge) into a form that is locally relevant and useful. They plan for worse, normal, and good scenarios based on the seasonal forecasts given by the meteorological department. This information is then disseminated to different stakeholders through participatory advisory bulletins. These bulletins include: advisories on the weather forecasts; explanations of expected hazards; proposed adaptation strategies, such as conservation agriculture practices; and the appropriate genetic material, including seed varieties that are best suited for particular AEZs and animal breeds that are most adaptable under the expected hazard conditions. The key off-farm services offered in Embu County are discussed below.

Early-warning systems enable farmers to know when and where to plant and when to move livestock in the event of climate hazards. The Kenya Meteorological Department (KMD) is responsible for the County's early-warning systems. It integrates scientific knowledge and traditional knowledge to generate seasonal forecasts and disseminates the information through pamphlets/ brochures and local radio stations that target farmers. Radio broadcasts are in local languages and the majority of the population have access to radios, making it an effective means of transmitting information. The pamphlets and brochures present information in a simplified and straightforward manner, but their effectiveness and reach is less understood.
The National Development Management Authority (NDMA) also provides early warning system services where they collect, collate, and analyse data to compile in early warning bulletins that are shared among stakeholders digit through emails, field monitors and barazaas. There are 12 NDMA sample sites that provide data about drought- and resilience- building activities.

Agricultural extension officers sensitize and train farmers on sustainable land management practices such as intercropping, conservation agriculture, terracing, water harvesting, composting, and agro ecological crop selection (e.g. green grams and cowpeas for drought resistance). Extension agents play a key role in supporting the adoption of improved farming practices and adaptive coping techniques through practical on-farm demonstrations. In Embu County, KALRO conducts on-farm trials, field demonstrations, and field day activities.

The LD provides extension services, training, field days, field visits, demonstrations and farmer field schools where the farmers are formed into groups to work communally through modules on demonstration plots or farms. Field schools typically include an enterprise component in addition to the production and adaptation components. In spite of this, agriculture extension services are compromised by the inadequate officer to farmer ratio in each of the four Sub Counties: Manyatta 1:780; Embu East (Runyenjes) 1:750; Mbeere North (Siakago) 1:650; Mbeere South (Gachoka) 1:680. At 1:2,000, the ratio for livestock farmers is even more concerning.

The Weather Index-based Insurance national project has been piloted in three wards in Embu County (Kieni South, Kagari South and Kithirio) and is expected to expand to three more wards in 2016. The government pays 50% of the premiums and the remainder approximately KES 100-200, on average) is paid by the farmer. In the pilot, 600 maize farmers with less than 5 acres of land bought premiums. This piloting will be scaled to complement or provide an alternative to private insurance and financial institutions that currently exist but are not particularly strong or widely used, such as Jubilee, UAP, and Kilimo Salama. This is evident from the low percentage of the households using these insurances, 1%, 0% and 5% for male, female and youth-headed households respectively.

At the same time, information regarding markets and marketing channels is weak and not uniformly distributed across the County. The various cooperatives that focus on production and marketing for different value chains often assume responsibility for providing market information for their members, as well as linking to direct buyers or markets. The banana value chain has the strongest cooperative structure, while the dairy value chain has the support of private processing entities. The maize and bean value chains are not well-informed or represented in terms of market information, storage and processing facilities.

Adapting agriculture to changes and variabilities in climate: strategies across major value chain commodities

Maize

	Provision of seeds and other inputs	On-Farm production	Harvesting storage and processing	Product marketing
Increased Temperatures	Low seed viability; low quality and quantity organic manures	Increased incidence of soil pests; loss of soil fertility inputs; high labour costs due to tilling (hard pan) and increased incidence of weeds	Infestation by storage pests (large grain borer); poor quality and low grain yields; reduction in processing activities	Increased grain prices due to high demand and low supply; reduction in marketing activies (promotion, sourcing external markets)
Magnitude of impact	Major-Minor	Severe-Minor	Major	Minor
Farmers' current strategies to cope with the risks	Use of indigenous seed preservation techniques (ash) as an alternative to pesticides; curing of fresh organic manure; use of certified seed	Delayed planting; terracing ; re-planting; cover crops; intercropping; agroforestry; use of animal (oxen) and manual labour (farmer groups) for land husbandry activities; application of fresh organic manure at planting; conservation agriculture; advice from extension agents	Use of chemicals to control storage pests; use of traditional methods of grain preservation (ash)	Grain outsourcing by processors; sale of grain locally (farm gate and within communities)
Other potential options to increase farmers' adaptive capacity	Promotion and use of certified seed; timely availability of certified seed to increase seed viability at planting	Capacity building on manure preservation techniques; research on drought torelant maize varieties; mechanized farming to reduce soil pests; diversification to other adaptable/profitable crop variaties; impoved access to small-scale irrigation equipment	Capacity building on the use of hermetic bags and silos; improved grain storage structures (granaries); improved access to government-owned storage strutucres (NCPB silos)	Establishment of cooperatives to faclilate marketing
Droughts	Lack of access to inputs (certified seeds, fertilizers, chemicals for pest and disease control)	Hard pans from reduced soil moisture and compaction; high labor costs (tilling and ploughing); poor stand establishment (seed loss though pests, rodents); poor soil quality; soil erosion; weeds prevalence	Infestation by storage pests (large grain borer); low grain yields and of poor quality; reduction in processing activities by millers	Grain processors challenged by high purchase prices arising from low yields and high local demand
Magnitude of impact	Major-Moderate	Severe-Major	Moderate	Severe
Farmers' current strategies to cope with the risks	Use of indigenous seed supply (neighbor to neighbor) and treatment systems (ash treatments); use of treated and certified seed	Delayed/ staggered planting; terracing and mulching to control soil erosion; re-planting; application of organic and inorganic soil fertility inputs; crop rotation; intercropping; agroforestry; manual weeding; advice from early-warning systems; tree planting; land leasing	Application of storage pesticides; use of hermetic bags; use of ash for grain preservation; construction of food storage granaries	Grain outsourcing for processing operations; sale of grain locally (farm gate and within communities)
Other potential options to increase farmers' adaptive capacity	Capacity building on certified seed; soil sampling to optimize fertilizer application	Capacity building on water harvesting, intergrated pest management, small-scale irrigation, livelihood diversification; research on drought-torelant varieties; improved access to advisory	Capacity building on post-harvest management strategies; construction and mantainance of storage structures (silos); increased availability of storage bags; research on effiecient storage systems and structures	Establishment of cooperatives to faclilate profitable marketing by producers; weather-based index insurance schemes to cushion grain losses

Banana

	Provision of seeds and other inputs 	On-Farm production 	Harvesting storage and processing 	Product marketing 
Moisture stress	Increased seedling loss at nursery stage	Increased seedling loss after planting and incidence of pest and fungal diseases; high labour costs for pest/disease control; reduced growth rate from poor soil property/ condition	Reduced fruit yields (tonnage); insufficient raw material for post-harvest processing	Scarcity of product on the market leading to increasing market price; reduced household incomes
Magnitude of impact	Severe-Major	Major-Moderate	Moderate	Major
Farmers' current strategies to cope with the risks	Use of irrigigation structures; shade layering in seedling nurseries; nursery establishment utilizing soil treatment; drenching; use of pesticides	Delayed planting; intercropping; agroforestry; diversification to other adaptable food crops; application of organic manures; on-farm water harvesting; use of pesticides; re-planting	Construction of community fruit grading sheds; covering fruit with green banana leaves to prevent moisture loss	Sale of banana locally (farm gate/community) and on external markets
Other potential options to increase farmers' adaptive capacity	Promotion of automated drip irrigation facilities; construction of improved seedling facilities (tissue culture)	Improved access to irrigation facilities (drip irrigation); breeding for shorter duration, diseases- torelant and high-yielding varieties	Construction of humidity-controlled packing houses; access to refrigeration and moisture-controllled storage facilities; value addition	Establishment of associations for banana produce marketing
Heat stress/ increased temperature	High seedling loss at nursery level; low quantity and quality of organic manure available	Delayed planting time and seedlings take-off; delayed application of fertilizers; increased infestation of sucking insects and diseases	Reduced fruit yields (tonnage); Reduced product shelf life; lack of storage structures; reduced opportunities in processing and value addition operations	Low production increases fruit market prices locally and externally; reduced market and marketing activities due to produce scarcity
Magnitude of impact	Major-Minor	Major-Moderate	Moderate	Major
Farmers' current strategies to cope with the risks	Use of shade nets to cover nursery seedlings; use of organic manure and sythentic biodegraders	Mulching of planted seedlings; application of organic fertilizers; on-farm water conservation; agroforestry; intercropping with cover crops; chemical (insecticides) and biological (predatorory insects) control	Covering produce with green banana leaves to prevent moisture loss; construction of communal storage shades (sheds) for temporary fruit storage	Sprinkling produce with water to reduce the moistrureloss of fruits
Other potential options to increase farmers' adaptive capacity	Access to water harvesting technologies; integration of banana with livestock farming; use of inorganic inputs to supplement organic fertilizers	Hedge tree planting as wind breaks; access to drip irrigation; research on pest and diseases control systems (focus on biological control); access to improved water harvesting technologies	Construction of cold storage facilities; use of refrigerated transporters; value addition activties	Access to refrigeration and moisture-controlled chambers; establishment of cooperatives and associations to facilitate marketing

Dairy (cow)

	Provision of inputs	On-Farm production	Harvesting storage and processing	Product marketing
High rainfall	Limited access to artificial insemination (AI), acaricides and feeds (pastures and concentrates)	Increased labour costs; high disease incidence; scarcity of feeds; destruction of housing units; reduced quality of feed sources	Milk spoilage due to inadequate storage facilities and transportation	Low prices for milk sale due to oversupply and low quality (waterly milk)
Magnitude of impact	Major-Moderate	Moderate	Moderate	Moderate
Farmers' current strategies to cope with the risks	Diversification of transport means to facilitate input access (boda boda)	Vaccination; deworming; prophylactic treatment; repair of animal husbandry structures (sheds/housing); establishment of fodder trees; afforestation; advice from bulletins, extension and development agents; feed conservation	Mechanization of milking process; existing graded roads ease transport challenges; installation of coolers and refrigeration facilities; value addition (fermented and powder milk)	Local (farm gate and community) milk sales; engagement with community associations for sale of milk
Other potential options to increase farmers' adaptive capacity	Improved access to farm machinery; improved transport infrastructure to facilitate input accesss; capacity buiding on feed conservation technology	Community-based livestock mass vaccinations; research and development on adaptive (diasease resistant) breeds, modernized livestock housing; capacity buiding on improved feed technnologies; improved waste processing	Introduction of levies from milk sale for road maintenance	Introduction of programs for external milk sale; establishing community-based milk reservesand cooperatives for negotiating activities in milk value chain
Droughts/ Increased temperature	Increased costs of breeding cattle and breeded calves; reduced fodder production; unavailability and unaffordability of disease- and pest- control inputs	Water scarcity; increased costs of feeds; poor sanitation; increased disease incidence; animal malnutrition; poor growth rates	Milk and meat yield reduction; reduced processing volumes; high incidences of milk spoilage; reduced household milk reserves	increased milk prices due to high demand and low supply; reduction in marketing activies
Magnitude of impact	Major-Moderate	Major-Moderate	Moderate	Moderate
Farmers' current strategies to cope with the risks	Diversification to locally available feed, pest- and disease- control supplements; reliance on early- warning systems	On-farm feeding; fodder conservation; feed supplementation; drought-resistant fodder varieties; improved water harvesting and storage facilities (pans); mass vaccinations; capacity building on animal husbandry; weather-based index insurances; improved access to advisory	Installatation of coolers and refrigiration facilities; value addition (processing to fermented and dry milk); scale-down milk processing plant operation during milk scarcity; enterprise diversification	Divertion milk to local and household consumption; scarcity of household milk reserve shifts to other eating habits
Other potential options to increase farmers' adaptive capacity	Establishment of county and communal drought funds; establish community strategic feed reserves; support to access inputs through county government and aid organizations	Construction of water storage structures (dams); capacity building on strategies for improved feeding (irrigation, drought resistant fodder/pastures); research on improved cattle breeds; design of improved feed rations and supplementation strategies; modernized cattle housing	Establishment of cooperatives to facilitate profitable milk sales; increased storage capacity for powdered milk; installation of coolers and processing plants	County and state government support to source for external milk markets; capacity building on regional milk marketing opportunities

Bean

	Provision of seeds and other inputs	On-Farm production	Harvesting storage and processing	Product marketing
Moisture stress	Low seed viability leading to poor germination	Reduced spraying due to poor stand establishment; delayed weeding; stunted growth and poor crop vigor (wilting)	Low yields (poor quantity and quality); lack of labour opportunities from poor grain harvests; household grain scarcity from crop failure	Reduced market activities leading to low household incomes; high market prices (grain scarcity and high demand)
Magnitude of impact	Minor	Major	Severe-Major	Severe
Farmers' current strategies to cope with the risks	Planting of drought-resistant seed varieties	Soil and water conservation through mulching, cover crops, agroforesty, intercropping, conservation agriculture; planting of early-maturing bean varieties; diversification to other crop varieties (root crops)	Application of storage pesticides	Local produce marketing at low farm gate prices
Other potential options to increase farmers' adaptive capacity	Improved access to irrigation facilities for continous cropping; shifting from inorganic to organic farming	Capacity building on conservation agriculture; breeding bean varieties tolerant to moisture stress; land leasing to more commerially-viable enterprises	Construction of improved storage facilities; establishment of community- and county-based strategic grain reserves	Training and empowering vulnerable groups on entrepreneurship and post-harvest opportunities
Droughts	Poor quality seeds leading to poor stand establishment; limited seed accesibility due to high costs; seed scarcity	Reduced agronomic performance through applied agrochemicals; hard pans increase labor costs	Poor yields (low quantity and quality) caused by crop failure; Lost labor opportunities in post harvest grain handling (winnowing and grading); household grain scarcity; increased incidence of storage pests	Reduced market activities resulting to low household incomes; High market prices driven by fruit scarcity and high demand
Magnitude of impact	Moderate	Major	Major	Severe
Farmers' current strategies to cope with the risks	Use of drought-resistant, short-maturing seed varieties; seed bulking; access to credit facilities for acquisition of farm inputs	Delayed land preparation and planting; increased incidence of weed, pest and diseases; diversification to alternative crops (legume) and enterprises (fish farming); water harvesting and small-scale irrigation; conservation agriculture; agroforestry; crop rotation; intercropping; crop loss protection through crop insurance	Application of storage pesticides	Establishment of strategic grain reserves at community and County level
Other potential options to increase farmers' adaptive capacity	Research on drought-resistant seed varieties; wide-scale bulking for seed multiplication; improved access to affordable credit schemes; use of organic manures	New intercropping strategies with newly-emerging food crops; soil and water conservation (harvesting and irrigation); greenhouses; tree planting	Training women and youth on post-harvest value addition activities	Capacity building on grain marketing strategies and marketing opportunities

Policies and Programmes

Several programs aimed at broadly addressing topics related to climate vulnerabilities have been put in place through the collaboration of local and international, public and private, and faith-based actors along with the community at large. The Small Holder Horticulture Marketing Programme, jointly sponsored by the Kenya Government and the International Fund for Agriculture Development (IFAD), started in 2007 and ran up to 2014. The program targeted poor rural households, unemployed and underemployed people in areas where horticulture is an important source of income. The program invested in value chains and market-derived infrastructure, and helped improve the supply of inputs and the functioning of marketing chains. Three modern horticulture markets have been completed and currently remain operational, namely: Kangaru, Kibugu and Karurumo. A fourth market, Kithimu market, is about 50% complete and the contractor is in negotiation with the National Government towards its completion.

The Small-scale Horticulture Development Project was started in the Mbeere North in the fiscal year 2008-09 with the overall objective to increase household incomes of small-scale horticultural farmers through improved productivity and enhanced marketing. The project is jointly sponsored by the African Development Bank and the Government of Kenya and includes three major components: irrigation and infrastructure development; farmer support in horticultural production; and marketing. The project is currently in the process of handing over the Kathiga Gacheru Irrigation Scheme to the County Government.

At the community level, the Siakago Community Grain Store project was started by the National Government and is comprised of the grain store itself together with necessary sanitary, drainage, internal plumbing, and lighting facilities. The store was handed over to the County Government in August 2015. The Diocese of Embu Caritas works at the community level but has an equally strong presence through its partnerships with other program and policy implementing entities. Over the years, DOE has collaborated with different stakeholders to help them develop their program activities through interventions at the local or grassroots level, as explained in Annex 5.

The Agricultural Sector Development Support Program (ASDSP) is a program funded by the Governments of Kenya and Sweden whose objectives is to transform Kenya's agriculture into an innovative, commercial oriented, modern industry as part of a larger strategy to alleviate poverty and improve food security. In Embu County, the ASDSP is involved in the facilitation and coordination of the participatory scenario planning with the key stakeholders in collaboration with Care Kenya. The ASDSP also works with key value chains actors, including cooperatives and County departments, towards developing and strengthening value-added practices in the indigenous poultry, banana, and dairy cow value chains. The program also focuses on environmental resilience and social inclusion.

The Upper Tana Natural Resource Management Project began in 2012 and is expected to run until 2020. This project is funded by the Government of Kenya, IFAD, the Spanish Trust Fund and the local community. The goal of the project is to contribute to the reduction of rural poverty in the Upper Tana River catchment. The program is envisaged to address two simultaneous development objectives: increasing sustainable food production and incomes for rural households in the project area, and the sustainable management of natural resources for the provision of environmental services. The approach to these goals revolves around four major components which include: community empowerment, project management and coordination, sustainable rural livelihoods, and sustainable water and natural resource management.

Governance, institutional resources, and capacity

In Embu, there are wide ranges of institutions, ranging from government to non-government to the private sectors, faith based organization that are actively involved in climate related issues; some of the most prominent institutions are discussed below.

The National Development Management Authority (NDMA) is a public body responsible for the overall coordination of all matters related to drought management. NDMA spearheads the contingency planning process of the climate risk management in the County, where it facilitates the steering committee's interaction with key stakeholders, including the County Government, Care Kenya, Action Aid, Catholic Caritas, Tro Care, and Kamurugu, amongst others, that discuss climate risk management and adaptations options and plan specific interventions. NDMA offers early-warning information to the farmers, mobilizes barazaas where farmers meet and share expectations and remedial options, publishes monthly bulletins for the community (and post them on their website), and monitors interventions through field visits. NDMA has 12 sample sites where data is collected in Embu County. Their key activities include developing resilience-building activities with the local communities, particularly in response to drought hazards.

KALRO is a government organization operating at regional level that is responsible for transmitting knowledge and technological development to the relevant stakeholders, primarily farmers and government departments (agriculture, livestock, etc.). In Embu, KALRO focuses

on: cereals like maize, wheat, sorghum, millet, and rice; grain legumes, such as dry beans, pigeon peas, green grams, and dolichos; and root and tuber crops, such as potatoes, sweet potatoes, cassava, yams and arrow roots. KALRO develops and promotes suitable natural resource management technologies including the training of farmers and staff, and the adoption of conservation agriculture through on-farm trials, demonstrations, and farmers field days.

The KMD generates seasonal forecasts through data analysis and workshops with key stakeholders: indigenous weather forecasters, the Departments of Agriculture, Livestock, Water, Health, Education, etc. Through participatory scenario planning, the experts develop a dissemination plan that may include information sharing through the ASDSP environmental resilient officers, NDMA coordinated barazaas, radio, etc.

NEMA works closely with key stakeholders to create awareness through barazaas and meetings that educate the public on the importance of tree planting and other adaptation strategies. NEMA produces County environmental action plans that include chapters on climate change risks, adaptation, and mitigation measures. NEMA is also responsible for creating the State of the Environment Report, in collaboration with key County stakeholders. NEMA takes the lead in the coordination and supervision of environmental activities. For example, during the world environmental day, they bring together communities to engage in environmental clean-up, tree planting, and exchanging of ideas. In Mazingira committee, they work closely with the Kenya Forest Service (KFS).

Care Kenya is an international organization active in Embu County by engaging in major programs that include refugee assistance, health, water and sanitation, financial inclusion, adaptation to climate change, disaster risk reduction, agricultural value chains and humanitarian and emergency response. Care Kenya promotes community-based adaptation to support the most vulnerable groups by empowering communities to work with other stakeholders in the design and implementation of programs and policies in the County. Care Kenya supports the development of community adaptation plans based on key problems identified by the community and works together with the community to propose solutions, later presented at Field Schools.

The International Centre of Insect Physiology and Ecology (ICIPE) in Embu East is actively involved in the promotion of integrated pest management (IPM) methods to control pests and diseases with a focus on the management of the mango fruit fly. ICIPE also helps to link farmers in the banana and sorghum value chains to markets.

Action Aid Kenya supports food security initiatives in the low-lying, semi-arid areas in Mbeere North and South, where they collaborate with other stakeholders, such as Care Kenya, to assist the communities in water harvesting techniques for crop production.

Another nationwide organization, the National Cereals and Produce Board (NCPB), supports local production efforts by storing surplus cereals from Embu County and distributing government subsidized fertilisers, Mavuno planting and top dressing, and CAN during cropping seasons.

As mentioned, the Diocese of Embu Caritas (DOE) covers five administrative sub-counties including, Embu East, Embu West, Embu North, Mbeere North and Mbeere South. The Diocese of Embu Caritas approach to development starts with a situation analysis, using the social mobilization tools such as participatory action research, which culminates in community action plans. The interventions planned are thus people centred, and developed according to the communities' priorities and available resources. Similarly, the Anglican Church of Kenya (ACK) is also a FBO in Embu County that is involved in providing extension services, the promotion of sunflower production and processing, supporting farmers with subsidized certified seeds and seedlings, and encouraging community mobilization activities to address a variety of cross-cutting issues.

Some of the most influential private sector actors in Embu County include agro-chemical companies and agro stockists, such as Farmchem, Twiga, Osho, Bayer Crop Science, and Sygenta etc. These private companies engage in the distribution and sale of agro-chemicals and other farm inputs and often train farmers on the safe usage of pesticides, fertilisers and other input supplies. Financial institutions such as banks (Equity Bank, Cooperative Bank, Kenya Commercial Bank, National Banks) and the Agricultural Finance Cooperation (AFC) provide loans and farm credit to farmers that can be used to purchase the inputs needed for production and storage activities. Kilimo Salama offer insurance services for farm enterprises in collaboration with agro dealers and financial institutions and Savings and Credit Cooperative Societies (SACCOS). They give out loans to farmers and offer a wide range of farm credit products including state-subsidized agricultural credit. The extent to which such formal financial institutions are accessible and used by farmers is not clear.

The various departments and institutions in Embu County lack proper coordination and collaboration thus leading to redundancies and duplication of roles in addressing and building resilience to climate change. There is a shortage of experts trained on climate-related issues. There are no

structured interdepartmental fora to discuss climate-related issues.

The capacity of the institutions is also challenged by funding. The bureaucracy and protocols that need to be followed for funding approval lead to delays in administering interventions. Lack of human resources also constrains the various institutions in carrying out their mandate, especially when it comes to the delivery of extension services. The absence of technical equipment is also evident, especially in the case of the KMD, where equipment for monitoring the automated weather stations is lacking.

Synthesis and Outlook

Climate Change is an all-encompassing issue and as such, cannot be tackled on an ad-hoc basis. An overarching strategy needs to be put in place that can be interpreted and incorporated into institutions' strategic design and work plans. Additional actors that have the capacity to play an active and proactive role in climate risk management should be brought on board. These may include teachers and actors from the education sector, where climate change issues can be incorporated into students' curriculum from an early age.

At the moment, there is no known policy tackling climate change in Embu County. Moreover, the various departments and institutions in the County lack proper coordination and collaboration thus leading to duplication of roles in addressing and building resilience to climate change. There is a shortage of experts trained on climate-related issues, and a great need for climate risk management training and extension services. These services should approach adaptation from a marketing and supply chain perspective, considering that farmers' ability to adapt to climate threats in the short and long-term will often require resource investment that seeks returns to incomes and improved livelihoods just as much as environmental sustainability.

As mentioned previously, climate hazards have serious impacts on the lives and livelihoods of Embu's farmers. These impacts include, but are not limited to: loss of livestock, destruction of farm produce and structures, crop failure and famine. The farmers have come up with adaptation options to tackle these impacts, however, they are insufficient to tackle the complexity of climate hazards. Additional adaptation options that could be considered for the livestock sector include: increasing storage capacity for powdered milk, a dairy levy for road maintenance to limit the high instances of milk spoilage, irrigated fodder production, more research and development on disease resistant breeds, mass vaccination and the establishment of a drought fund/ strategic feed reserve as a precautionary measure in the event of drought. In crop production, key opportunities refer to the construction of cold storage facilities and refrigerated transport in the banana value chain and seed bulking. In addition, solution to marketing challenges include the strengthening of farmers' cooperatives, value addition and development of market infrastructure.

The majority of the farmers rely extensively on rain-fed agriculture, which is unreliable in the hot and dry semi-arid low lying areas of Mbeere North and South. Water harvesting for crop and livestock production, development of irrigation schemes to increase yields during the dry seasons through smallholder irrigation schemes with public/private partnerships are required to tackle water shortages. In addition, there is an evident need for the promotion of drought-tolerant crops, efficient water-use technologies (drip irrigation, green houses) and conservation agriculture to cope with the recurrent climate shocks experienced in these zones.

The high cost of farm inputs is a challenge in the County as most of the farmers are not in a position to afford expensive inputs. This is further exacerbated by climate risks, which increases demand for agricultural inputs, resulting in scarcity of inputs and higher prices. In this sense, there is a need for coordination of farmers through farmer groups to acquire these inputs, subsidized inputs by the government through the NCPB and the Kenya Cereals Enhancement Programme, as well as improved access (affordability) to farm credit provided by financial and alternative lending institutions.

Land fragmentation (the average small-scale farm size is 1.98 acres) is a factor limiting agricultural activities in the County. Implementation of sound land policies both at national and County level are required to address these issues.

Additionally, improved storage facilities and technologies such as hermetic bags and community grain and input storage facilities can help avoid post-harvest losses. This would increase the value of the produce and lead to higher trading prices in the market. Better coordination among key stakeholders such as research institutions, financial institutions, the department of agriculture and the community to develop and promote these facilities will be required.

For further information and access to the annexes, visit https://cgspace.cgiar.org/handle/10568/80452

Annex 1: Irrigation Schemes in Embu County
Annex 2: Crop systems in Embu County
Annex 3: Climate analysis
Annex 4: Adaptation strategies in Embu County, as defined by ASDSP
Annex 5: Agriculture and climate-related programs directed by Catholic Caritas and partners in Embu County

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