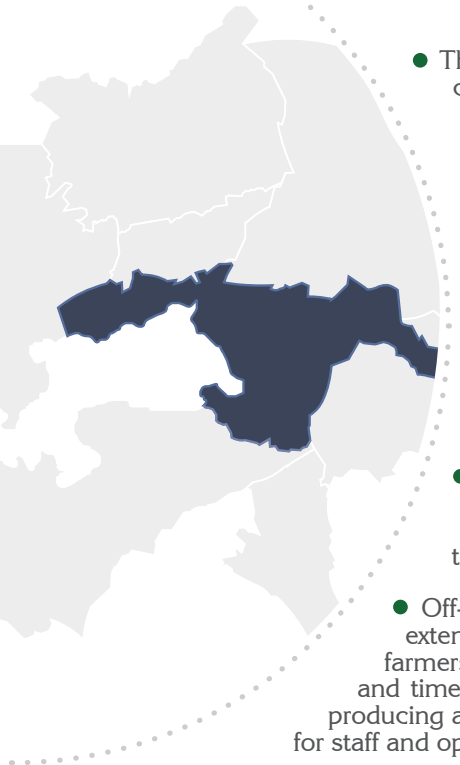
Climate Risk Profile
Kisumu County

Highlights

- In Kisumu County, agriculture contributes almost half of household incomes and represents a key agent for the population's food security. In 2012, major food crops produced in the County (maize, sorghum, and beans), generated approximately 10 billion of Kenyan Shillings (KES), cash crops (sugarcane, rice, and cotton) another KES10.5 billion, and livestock products KES1.5 billion. Female-headed households generally earn higher on- and off-farm incomes compared with the male-headed ones, as women tend to diversify their activities, be more actively engaged in farmer groups and cooperatives, and engage in high-value crops production.
- Small-scale production represents 90% of total agricultural production, 75% of total agricultural output, and 70% of marketed agricultural produce in Kisumu County.
- Food insecurity, unaffordable health care, poor water and sanitation systems, lack of title deeds, and the impacts of erratic and unreliable rainfall and climate hazards magnify the already high poverty incidence in the County. Roughly 40% of the people are poor and another 61% are considered food-poor.



- The predominant reliance on rain fed systems increases farmers' exposure and vulnerability to climate variability and change. In recent years, floods, droughts, and heat stress have become more frequent, intense and unpredictable, leading to significant losses to agriculture and livelihoods.
- On-farm measures taken up by smallholder farmers to cope with an unpredictable climate include change of crop type, staggered planting, infield soil and water conservation practices, and use of food preservation and processing techniques.
- In general, male-headed households undertake post-harvest handling activities, such as construction of food storage facilities, establishment of communal seed banks, and value-added processing. Female-headed households are more likely to invest in longer term strategies to improve yields and ensure sustainable production, such as increased use of irrigation infrastructure, water harvesting, staggered cropping, change of crop type. These may relate to differences in access to information and productive resources.
- Despite heavy involvement of women and youth across the value chain stages, efforts should be made towards increasing their economic gains and improving decision making powers. Highly targeted interventions (especially in the postharvest and marketing stages) that support these benefits should be considered.
- Off-farm services to improve farmers' resilience to climate change, including early warning systems, extension and training, storage facilities, credit, insurance and market information are offered to farmers by public, private, non-profit and local institutions. However, the capacity to deliver relevant and timely support to farmers within the County is limited by a lack of institutional coordination in producing and delivering information, poor road infrastructure to reach farmers, and resource availability for staff and operations.
- Most of the institutional support for farmers goes to the input supply and production stages, and less on post-harvest, value-addition, and marketing phases of the value chain.
- Despite the existence of a wide range of financial institutions (banks, insurance companies, and corporations), most of the credit facilities and insurance services available to farmers require clear title deeds as collateral and incur high interest rates, discouraging the use of such financial products and even farmers' engagement in agri-business.

KCSAP
Kenya Climate Smart Agriculture Project
Republic of Kenya
WORLD BANK GROUP

List of acronyms

ASDSP	Agricultural Sector Development Support Programme
AEZ	Agro ecological Zone
ABCIC	African Biodiversity Conservation and Innovation Centre
AFC	Agricultural Finance Corporation
ATC	Agricultural Training Centre
ASDS	Agricultural Sector Development Strategy
ASDSP	Agricultural Sector Development Survey Programme
AWS	Automated Weather Station
CBO	Community-based organization
CIDP	County Integrated Development Plan
CREP	Community Rehabilitation and Environmental Protection
CSV	Climate Smart Village
DA	Department of Agriculture
DANIDA	Danish International Development Agency
DGECC	Department of Green Energy and Climate Change
DF	Department of Fisheries
DFPA	Danish Family Planning Association
DL	Department of Livestock
DVC	Department of Veterinary Services
EnDev	Energizing Development
ERA	Economic Review Agriculture
FAO	Food and Agricultural Organization of the United Nations
FHOK	Family Health Options Kenya
FOKO	Friends of Katuk Odeyo
GHG	Greenhouse gas
GIZ	German Development Agency
GOK	Government of Kenya
HFMD	Hand- foot- mouth diseases
IDA	International Development Agency
ILRI	International Livestock Research Institute
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KALRO	Kenya Agricultural Livestock Research Organization
KCB	Kenya Commercial Bank
KCSAP	Kenya Climate-Smart Agriculture Project
KEFRI	Kenya Forestry Research Institute
KENAFF	Kenya National Association of Federation of Farmers
KFS	Kenya Forest Services
KICOPE	Kisumu County Poultry Enterprise Cooperative Society
KIPOTRA	Kisumu Poultry Traders Association
KMD	Kenya Meteorological Department
KMFRI	Kenya Marine and Fisheries Research Institute
KNBS	Kenya National Bureau of Statistics
KOAN	Kenya Organic Agriculture Network
KWS	Kenya Wildlife Service
LBDA	Lake Basin Development Authority
MoALF	Ministry of Agriculture, Livestock and Fisheries
MFCPS	Muhoroni Farmers' Cooperative Poultry Society
NCPB	National Cereals and Produce Board
NCCAP	National Climate Change Action Plan
NCCRS	National Climate Change Response Strategy
NCD	Newcastle Disease
NEMA	National Environmental Management Authority
PICS	Purdue Improved Crop Storage
PSP	Participatory scenario planning
TIMP	Technology, innovation, and management practice
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
VCC	Value Chain Commodity
WEMA	Water Efficient Maize for Africa

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 highly susceptible to climate-related hazards, and in many areas, extreme events and variability of weather are now the norm; rainfall is irregular and unpredictable; while droughts have become more frequent during the long rainy season and severe floods during the short rains. The arid and semi-arid areas are particularly hard hit by these climate hazards, thereby putting the lives and livelihoods of millions of households at risk.
In 2010, Kenya developed a National Climate Change Response Strategy (NCCRS), which recognized the importance of climate change impacts on the country's development. This was followed by the National Climate Change Action Plan (NCCAP) in 2012, which provided a means for implementation of the NCCRS, highlighting a number of agricultural adaptation priorities. The focus of these initiatives has been at the national level, there is need to mainstream climate change into county level policies, programmes, and development plans; therefore ensuring locally relevant, integrated adaptation responses with active involvement of local stakeholders.

The Government of Kenya (GoK) through the Ministry of Agriculture, Livestock and Fisheries (MALF), with funding by the International Development Agency (IDA-World Bank Group) is therefore implementing the Kenya Climate-Smart Agriculture Project (KCSAP). This projects objective is to increase agricultural productivity and build resilience to climate change risks in targeted smallholder farming and pastoral communities in Kenya, and in the event of an eligible crisis or emergency, to provide immediate and effective response. This Climate Risk Profile has been conducted within the framework of KCSAP and aims to inform county governments and stakeholders on the climate change risks and opportunities for agriculture so they are able to integrate these perspectives into county development.

This document presents the Climate Risk Profile for Kisumu County which has a climate vulnerability index of 0.448[1], a region where more than 5,000 people are affected annually by floods (particularly in the months of April to June and October to November), due to damages caused to properties and agricultural crop losses of 80-100%. In the Kano plains, yearly flood-related losses are estimated at US$ 850,000 (Masese et al, 2016), while relief needs amount to US$ 600,000. Such events represent major barriers to food security and poverty alleviation efforts in the County. As precipitation is likely to increase in intensity and unpredictability and flood risks are expected to become imminent in the future, concerted measures to increase the resilience of the rural population to the adverse effects of climate change are required.

The profile is organised into six sections, each reflecting an essential analytical step in understanding current and potential adaptation options in key local agricultural value chain commodities. The document first offers an overview of the county's main agricultural commodities key for food security and livelihoods as well as major challenges to agricultural sector development in the county. This is followed by identification of the main climatic hazards based on the analysis of historical climate data and climate projections including scientific assessment of climate indicators for dry spells, flooding and heat stress among other key climate hazards for agriculture. The document continues with an analysis of vulnerabilities and risks posed by the hazards on 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 enabling policy, institutional and governance context for adoption of resilience-building strategies. Finally, pathways for strengthening institutional capacity to address climate risks are presented.

1 The national climate vulnerability index average is 0.4317.http://hdr.undp.org/sites/default/files/knhd_report_2013.pdf

Agricultural context

Economic relevance of farming

The County is home to the third largest city[2] in Kenya, Kisumu, and covers a total land area of 2085.9 square kilometres (km^2)[3] (GoK, 2012). It is bordered by Homa Bay County to the South, Nandi County to the North East, Kericho County to the East, Vihiga County to the North West and Siaya County to the West.

Agriculture plays a major role in the economic growth and development of the County, contributing 47% to household income. Slightly less than two thirds (62%) of all households in Kisumu County[4] depend on crop farming for their livelihoods (GoK, 2012). On average, agricultural income amounts to 82,482 Kenyan shillings (KES) per household per year and is generated from crop faming (40% of on-farm income), fish (23%), and livestock (11%). Female-headed households normally earn more income compared with the male-headed ones, as women tend to diversify their activities, are more actively involved in farmer groups and cooperatives, and engage in high-value crops production (GoK, 2014). The agricultural sector also provides raw materials to the manufacturing sector and therefore stimulates non-farm incomes and employment (GoK, 2012).

The main subsistence crops include maize, sorghum, rice, bean, finger millet, cassava, potato, groundnut, and kale (GoK, 2014). In 2012, major food crops produced in the County were valued at approximately KES10 billion; maize was the highest contributor, accounting for 56% of the total food crops' value (KES5.7 billion), followed by sorghum (KES1.9 billion, equivalent of 20% of the total food crops value), and beans (KES 1.4 billion, 14.6%) (GoK, 2014). Key cash crops cultivated in Kisumu are sugarcane[5], rice[6], and cotton[7], all of which generated approximately KES10.5 billion in 2012[8] (GoK, 2014).

Fishing is one of the key economic activities in Kisumu County, especially around Lake Victoria. With the introduction of aquaculture, households have been increasingly investing in pond construction and maintenance. There are over 1,330 fish farms, 3,275 fishermen, and 189 fish farm families in the County. The most common fish include omena, tilapia, and Nile perch, which generate incomes of KES12 million, 28 million, and 11 million per year, respectively. The fish is sold locally[9] and also processed for export (GoK, 2013).

In 2013, livestock production generated KES1.5 billion (GoK, 2014). On average, 93% of the households in Kisumu County rear chicken, 47% keep cattle, and 39% keep goats and, 24% hold sheep.

Some of the main non-agricultural (informal) activities in the County include *boda boda*[10] (especially in Kisumu City), small-scale trading (shop vendors), tourism , and, to lesser extents, recreational sailing and fishing.

People and livelihoods

In 2009, Kisumu County had a population of 968,909 people[12], 35% of whom were categorized as youth (15-29yrs). The County's total population is expected to increase by 13.4% by the end of 2017, totalling 1.1 million people[13]. Roughly 70% of the people live in rural areas, most of whom are women; rural-to-urban migration is particularly high among men, who move to urban centres such as Kisumu, Ahero, Maseno, Chemelil, Muhoroni, and Awasi, in search for off-farm jobs.

Literacy levels are fairly high in Kisumu County, where 82% of the population can read and write. However, poverty remains pervasive in both urban and rural areas[14]. The poverty index has been estimated at 40%[15] (GoK, 2012) and is closely tied to HIV and

2 Following Nairobi and Mombasa.

3 Area under water in Kisumu County is equivalent to 567 km^2.

4 A typical household in Kisumu County has 6 members (GoK, 2014). There are approximately 226,000 households in the County (GoK, 2012, 2009).

5 Predominantly grown in the lower midlands (Maseno, Muhoroni and Miwani

6 Grown especially along the Rivers Nyando and Awach, Chemelil, Miwani and Kibos.

7 Cultivated mainly in Kadibo and Nyando.

8 KES9, 956 million from sugarcane, KES400 million from coffee, and KES123 million from cotton production.

9 Within and outside the county

10 Refers to transportation services using motorbikes and bicycles. The activity is especially common among male youth in urban and rural areas.

11 Tourism is mainly developed around Lake Victoria, Ndere Island National Park, the Kisumu Impala Sanctuary in Kisumu City, the National Museum in Kisumu and Songhor Paleontological Site in Muhoroni. Others are the viewpoints in Nyabondo, the Luanda Magere site in Miwani and Kit Mikayi in Kisumu West.

12 The youth represent 35% of the total population and they contribute significantly to the labor force in the County.

13 Average national population growth rate is estimated at 3.1% per year.

14 Incidence of poverty is slightly higher in the cities (70%), compared with rural areas (63%).

15 For the same year, the national poverty index was estimated at 45%, representing almost 17 million people.

AIDS[16], the collapse of local agro-based industries, a high unemployment rate (estimated at 13%)[17], and low agricultural production. Food insecurity, inaccessibility to affordable health care, poor water and sanitation systems, poor and inaccessible road network, and lack of title deeds, erratic and unreliable rainfall, frequent floods, malaria, and waterborne diseases magnify the already high poverty incidence (GoK, 2012). Around 61% of the population (369,837 people) is considered food-poor. This condition is manifested through high rates of children stunting and wasting (14% and 8% of the children, respectively) (GoK, 2012).

Average land holding size in the County amounts to 1.6 acres (roughly 0.6 hectares [ha]) and the holdings are highly fragmented, which discourages economies of scale and long-term investments and ultimately leads to further pressure on the natural resource base. Most of the land (79%) is owned by individuals, 5% is clan/ family-owned, 0.4% is communally-owned, and the rest is owned by various local authorities. The incidence of landlessness is relatively low in the County[18] (GoK, 2012).

The mean distance to the nearest water point is one km. Nearly half of the households (47%) spend less than five minutes (one way) to fetch drinking water. Around 55% of the households have access to potable water, while only 8% have access to piped water. About 59% of the households in Kisumu County rely on fuelwood for cooking and only 18% of the population have access to electricity for lightning. However, this percentage is likely to increase, as the electricity is being subsidized under the current governmental rural electrification programme.

Agricultural activities

Agriculture is the mainstay of the population in the County, where mixed farming systems predominate; only a few farmers cultivate sugarcane and rice for commercial purposes under mono-cropping systems. Approximately 34% of the land in the County is dedicate to subsistence crops, 34% to natural pastures, and 18% to commercial crop production; homesteads extend over 7% of the land (GoK, 2014). Small-scale production[19] represents 90% of total agricultural production in the County; it accounts for 75% of the total agricultural output and 70% of the marketed agricultural produce. Some nucleus estates are established around sugarcane factories in Muhoroni and parts of Nyando Constituencies.

The County is mainly dominated by sandy and clay soils. In the Kano Plains, (a topographical zone lying in the floor of the rift valley) the dark-brown and grey soils are poorly drained, and usually very deep and firm. The black cotton soils constitute more than 70% of all soil types found in Kisumu County and are suitable for brick making and sand harvesting especially at Maseno and Nyakach.

Altitudes vary from 1144 metres on the plains to 1525 metres. in the Maseno and Lower Nyakach areas, strongly influencing rainfall and temperatures in the County. The mean annual rainfall varies with altitude and proximity to the highlands, along the Nandi Escarpment and Tinderet. These areas have two rainy seasons; the long rains usually occur between March and May and the short rains occur between October and December. Rainfall data indicates that the county receives substantial rainfall[20]. During the short rains, the average annual rainfall ranges between 450 mm and 600 mm (GoK 2012). The mean annual maximum temperature ranges between 25°C and 35°C, while minimum temperatures range between 9°C and 18°C.

Agricultural potential varies by agro-ecological zone (AEZ). Seven AEZs[21] can be distinguished in the Kisumu County (Jaetzold and Schmidt, 1983), namely:

- The coffee zone (UM1), which includes a very small area near Maseno; The main coffee zone in Koru (UM2); annual temperatures 19.7-21.0^{0}C, Average rainfall 1050-1400mm.

- The marginal coffee zone (UM3), which includes areas of Koru, also popular for finger millet, bean, sweet potato, sunflower (Kenya Fedha and Shaba), soybean (magoye), onion, cabbage, and other vegetables. Annual mean temperatures are 20.2-20.8^{0}C with average annual rainfall being relatively high at 1050-1400mm.

16 This affects mostly the economically active population (people aged 20-49 years).

17 Unemployment is higher among women (15%) compared with men (11%). While for women illiteracy remains a major barrier to job security, youth unemployment is associated with a lack of start-up capital and entrepreneur skills

18 Higher rates of landlessness are found in the areas near Muhoroni..

19 Average size of small-scale farms is below 1 ha, while large-scale farms are, on average, around 6 ha. Large-scale production accounts for 30% of the marketed agricultural produce in the County.

20 Mean annual rainfall amounts to 1630 mm in Maseno, 1525 mm in Muhoroni, 1290 mm in Kibos, 1280 mm in Kisumu, 1260 mm in Ahero and, and 1103 mm in Koru. The lowland area receives, on average, between 1000 mm and 1800 mm of rain annually.

21 These AEZs have also been classified into sub-humid to humid areas (zone I-III) (GoK 2013).

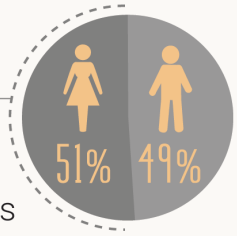
Livelihoods and agriculture in Kisumu

Demographics

ND Of Kenya´s population

968,909 inhabitants

48% Live in rural areas



Access to basic needs

40% of the population lives in **absolute poverty**

Potable water	55%
Electricity for cooking	0.1%
Electricity for lighting	18%
Education (youth literacy rate)	ND

Food security

61% of the population suffers from **food poverty**

ND of household **income spent on food**

ND People **undernourished**

14% Children **stunted**

ND 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)

Farming

County´s farming area

134,200ha

64%

62% of the population employed in agriculture production

ND of farmers have title deeds

ND are women

Farming activities

Food crops

34%

Cash crops

18%

Of county´s agricultural land

Livestock

0 Group ranches

0 Company ranches

Farming inputs

Water uses

ND ND 3%

Fertilizer types (% of households)

18% Organic manure

5% Planting fertiliser

6% Top dress fertiliser

Pesticide types (% of households)

3% Field pesticides

5% Storage Pesticides

3% Herbicide

- The lower midland sugarcane zone in Chemilil (LM1); Annual mean temperatures 21-22.40^{0}C, average rainfall 1450-1600mm.

- The marginal sugarcane zone (LM2)[22], with very good yield potential, covering areas like Muhoroni and Nyakach. The area is also home to other crops, including sunflower (Kenya Fedha and Shaba), soybean (magoye), chilli, sweet potato, and cucumber. Crops such as maize, sorghum, finger millet, bean, dolichos bean, cowpea, pigeon pea, groundnut, tomato, onion, pumpkin, kenaf, and roselle, also have a high potential for cultivation in the zone. Annual mean temperature ranges from 20.9-22.3^{0}C, average rainfall 1400-1600mm.

- The lower midland cotton zone (LM3), which including areas such as Ahero, Miwani, and Rabuor and where rainfall (1100mm -1350mm) allows for two planting seasons, in August and December.

- The marginal cotton zone (LM4), where green gram, cowpea, chick pea, soybean, groundnut, pigeon pea, are cultivated. Annual mean temperatures 22^{0}C, Average rainfall 950-1100mm.

Seeds, fertilizers, pesticides, and vaccines are available to farmers through agro dealers, county governmental departments (Department of Veterinary Services [DVS]), and private service providers. Fertilizer use is low; approximately 17% of the farmers use organic manure, 5% basal fertilizer, and 6% top dressing fertilizer. Some few farmers (2.5-2.6%) use field pesticides and herbicides for select annual crops (maize, beans, green grams, rice and sorghum). Around 4% of the farmers use storage pesticides to avoid post-harvest losses. As agriculture is mostly for subsistence, very few households hire additional labour. Almost all farmers resort to simple farm equipment, such as the ox plough and the hoe.

Crops are usually stored in the houses, traditional on-farm granaries and cribs, but also at off-farm facilities, such as the National Cereals and Produce Board (NCPB) in Kisumu. Some farmers have established or joined farmer groups and cooperatives for bargaining power, yet the majority of the farmers sell the surplus individually.

Agricultural value chain commodities

A broad diversity of agricultural commodities is grown in the Kisumu County. Of these commodities, various value chains have been prioritized as being strategic for the County, as indicated in the County Integrated Development Plan (CIDP) and the Agriculture Sector Development Support Programme (ASDSP), as well as by government institutions such as the Kenya Agricultural and Livestock Research Organization (KALRO). For the development of this County Climate Risk Profile, four major value chain commodities (VCC) were selected for in-depth analysis based on: alignment with County priorities (as expressed in frameworks and programmes), economic value (KES/bag or KES/livestock or KES/unit of livestock product), resilience to current weather variability and future climate change[23], and number of economically active people engaged in the commodity's value chain (including vulnerable groups, women, youth and the poor[24]). The selected value chains are cowpea, sorghum, cassava and local chicken.

Leafy cowpea

Cowpea, known as *boo* by the locals, is a key staple food and livelihood source in Kisumu County. Its leaves are boiled and served as a side-dish to maize meal (ugali) and other starchy foods, such as cassava. Dried cowpea leaves are sometimes stored for use in the dry season, when fresh leaves are unavailable. Between 2012 and 2013, the area under cowpea production in Kisumu County reduced by two thirds (66%), from 3,880 ha to 1,304 ha; so did total production, which experienced decreases by 32%, from 19,400 tonnes to 13,184 tonnes during the same time period. In 2014, the cowpea area increased slightly to 1,462 ha, while yields remained low (9-10 bags/ha) (GoK, 2015).

Little information is available on the leafy vegetable varieties, since most research has focused on the grain cowpeas. However, some common varieties include K80, M66, and KVU 27-1.Cowpea is commonly cultivated by small-scale, resource-constrained farmers in various AEZs, including LM2 (in Nyakach areas), where the crop is grown under small, mixed farming systems[25]) and LM3, where cowpea is cultivated on large scale, commercial, and mixed farms (includes

22 This zone overlaps with the upland e.g. Nyakach and midland e.g. Muhoroni topographical zones.

23 Value chain commodities are considered more resilient if they are able to withstand climate conditions, given the current production systems and holding other aspects constant (including variations in technology adoption rates among farmers/pastoralists).

24 The category of "poor" people was based on workshop participants' perceptions and not on a specific poverty measuring standard.

25 Includes cattle and local chicken and crops such as maize and sorghum.

areas such as Ahero, Rabuor, Onjiko, Miwani, Awasi). The crop thrives with minimal or no fertilizer and it is not labour-intensive. Even though it grows best with consistent and well-distributed irrigation, cowpea is heat- and drought-tolerant.

Cowpea seeds are readily available on local markets, and most farmers use family labour, ox plough and simple farm tools (hoes) for growing and harvesting the crop. The crop is collected, bulked, and later transported to various market centres across the county, such as Katito, Sondu, Ahero, Chemilil, Holo, Maseno, Awasi, and Pap Onditi. In the absence of cooperatives that can support the commercialization of cowpea in the County, farmers have established groups to facilitate links with buyers, negotiated pricing, and selling of products (leaves and peas).

Sorghum

Sorghum is widely cultivated throughout the entire County, given the crop's resilience to climate shocks. Despite decreases in cultivated area between 2012 and 2014 (from 11,645 ha to 11,082 ha), total production increased by 65%, from 131,370 tonnes to 225,150 tonnes over the same period (GoK, 2015). This could be attributed to the changing of crop types (from staples such as maize) as an adaptation to a changing climate and the food and nutritional security provided by the sorghum crop.

Sorghum production occurs mostly under small-scale, subsistence, mixed farming systems. While seed supply is generally ensured by local agro dealers, many farmers still recycle the seeds. Institutions such as KALRO and the African Biodiversity Conservation and Innovation Centre (ABCIC) have played an important role in developing and disseminating new crop varieties that are better adapted to climate variability and shocks, including KARI Mtama-4 and Seredo. Very few farmers afford the use of fertilizers to grow the crop.

Processing and bulking is mostly within the households, using Purdue Improved Crop Storage (PICS) bags. Sorghum is dried in an open environment to minimize aflatoxin contamination and to avoid heaping and dumping of wet sorghum heads, which can enable the growth of mycotoxin-producing fungi and ultimately lead to post-harvest losses. Some farmers also use silos of the cereal board (NCPB) Kisumu City. There are no active cooperatives to support collective marketing of sorghum; however Jubilee National Produce Board in Awasi is a major retailer of sorghum produce. Other towns with vibrant market centres include Katito, Ahero and Sondu.

Cassava

Cassava constitutes a key source of dietary energy for low-income consumers and provides a stable food base in drought-prone areas. Small amounts of the crop are used as agro-industrial livestock feeds and for starch production. For human consumption, roots are boiled or eaten raw.

Cassava is mainly grown in Ahero, Miwani and Rabuor regions (LM3), but also in the areas of Maseno (UM1, UM2) where mixed, commercial, and medium-scale production systems prevail. Approximately 41-60% of the population is involved in the cassava value chain. The area under cassava production and the total quantity of the crop produced decreased slightly between 2012 and 2014[26], while yields have shown an increasing trend, from 10 tonnes/ha to 11 tonnes/ha over the same period (GoK, 2015). Cassava commercialization is limited and only a few processors are available; however industries such as textiles, pharmaceuticals, brewery, paper and paper board manufacturers, adhesives, and dry cell manufacturers could be potential outlets for cassava by products.

Farm Africa has introduced new early-maturing, disease- and drought-tolerant varieties of cassava. They have also invested in training farmers in Nyando on the management of the new variety so that they could further disseminate the knowledge. The Community Rehabilitation and Environmental Protection (CREP) Programme promotes the use of improved cassava seeds (MM96/0183, MYGERA, SS4, TM14, UKNOWN 1&2) as a component of its food security package. On its part, KALRO has been active in promoting clean and certified varieties.

Planting occurs mainly during the long rains (February/March) and maturity is reached after 8-12 months. Farmers rely heavily on the extension advice offered by public and private actors such as the Department of Agriculture (DA) and Farm Africa. While some farmers receive trainings on input management through the Kenya Organic Agriculture Network (KOAN), others many still use inorganic fertilizers for growing their cassava crops.

Many cassava growers chip and dry the crop[27] as a measure to reduce post-harvest losses, others

26 The area under cassava production reduced from 2,865 ha in 2012 to 1,106 ha in 2014 and the total quantity produced went down from 28,650 tonnes to 12,205 tonnes during the same period.

27 Farm Africa has played an important role in providing farmers with trainings on such crop conservation strategies. https://www.farmafrica.org/kenya/cassava-farming

process it into flour or turn the peeled roots into dried fermented or unfermented chips, adding value to the product. Crisps, *chapatis*, and *mandazis* contribute to the consumer's nutrition and contributes to greater consumption of the crop. This value chain has received considerable support (new disease tolerant varieties with high yields, teaching value addition) from farmer groups (such as Kamicha Kabondo) and other public actors (DA, KALRO) when it comes to product commercialization.

Chicken (local)

The vast majority of the population in Kisumu County keep local chicken, be it under free range (traditional), semi-intensive (backyard), or commercial-intensive production systems[28]. Subsistence poultry production occurs throughout all AEZs (especially in Wathorego and Ulalo), while medium-scale production is most common in Miwani (LM3) and Chemelil and large-scale production at Pap Onditi and Katito (LM2). Most farmers keeping chicken are women and children.

Supplementary feeding and the use of additional inputs (sorghum for energy, sunflower cake for protein, millet) is minimum, as indigenous chicken freely roam around homesteads and scavenge for food. Due to the informal nature of the production process, information related to inputs and production volumes and quantities is limited. Farmer groups and the Kisumu County Poultry Enterprise Cooperative Society (KICOPE) are actively engaged in the production stage, facilitating access to management-related extension/ advisory services. The DVS and private service providers supply subsidised vaccines to the farmers to prevent disease outbreak.
The Kisumu Poultry Traders Association (KIPOTRA) is engaged in chicken processing activities (DE feathering, slaughtering) and marketing, while the Muhoroni Farmers' Cooperative Poultry Society (MFCPS) support the farmers' linkage to buyers and sellers by partnering with local actors such as hotels.

Agricultural sector challenges

Access to safe water for human consumption and agriculture constitutes a major challenge for the population in Kisumu County. As per the latest census, less than one percent of the households had access to piped water in their dwellings and another seven percent had to acquire piped water elsewhere (GoK 2013). A large proportion 41.7% rely on springs wells and boreholes while 37.6% fetch their water from the streams, 7.9% from ponds. In spite of many water sources most are unsuitable for drinking, due to the high concentration of pollutants from effluent discharges from factories (especially along Nyando River), sediment loading from upstream farms, and siltation[29]. This situation is exacerbated during the rainy season, when flooding affects the quality of water sources (especially in Nyando, Nyakach, and Muhoroni areas), causing damages to crops and properties and increasing the risk of waterborne diseases[30]. During the dry spell, some water sources dry up, compelling inhabitants (especially women and children) to travel even longer distances to fetch the water. This also drives conflicts among water users[31].

Crop and livestock production is affected by a wide range of pests and diseases e.g. stalk borers, smut, and aphids in sorghum, the East Coast Fever[32] in cattle, Newcastle disease, Gumboro disease, Fowl typhoid, and Coccidiosis in the chicken value chain, tsetse flies[33], lung infections (pneumonia), worm load, and parasitic infections of worms in livestock. During the dry spells, there are cases of hand-foot-mouth diseases (HFMD) or even anthrax (in Nyakach Sub-County in particular) which lead to serious livestock and economic losses.

Land tenure and management is another challenge to agricultural production in the County. In the absence of clear title deeds and land delimitations, open grazing is a common practice, causing damages and even losses to crops due to animal interference. Moreover, population growth and cultural inheritance norms have led to further pressure on natural resources, leading to high land fragmentation that threatens the economic efficiency of agricultural production systems of most farmers.

Access to markets becomes especially difficult during the rainy season, due the poor road infrastructure that gets affected by rains and floods. Moreover, for not being part of cooperatives and group structures, farmers lose their bargaining power to intermediaries and brokers, since they are unable to fetch good prices for their products, to access credit, and pool resources for value addition. Despite the existence of

28 In 2014, 78% of the poultry production in Kisumu County came from indigenous/local chicken.

29 The three major rivers flowing into the Winam Gulf, namely Nyando, Kibos and Sondu are heavily silted, resulting in the extensive formation of lakeside swamps.

30 Parts of the Winam Division (namely Kolwa East, Kolwa Central, Kolwa West, Kadibo's Bwanda and Kawino locations) are particularly vulnerable to seasonal flooding.

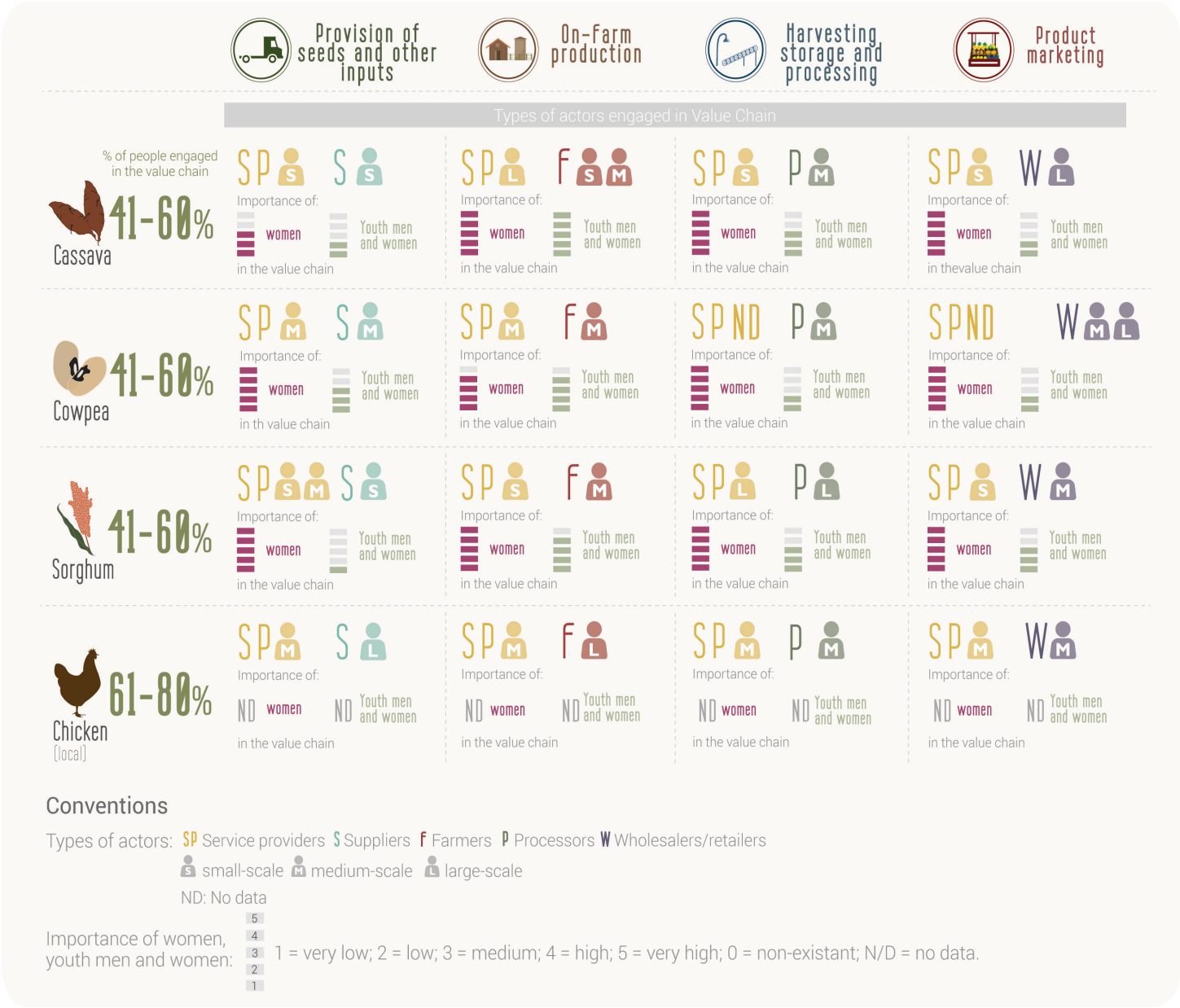
31 Sporadic pasture conflicts along Chemase-Chemelil border have resulted in deaths, displacements of people, and destruction of properties.

32 The disease is transmitted through ticks during the rainy seasons, when increased vegetation boosts the prevalence of ticks. This is a County-wide menace to livestock.

33 Especially around areas of Nyakach, areas in adjacent to the lake in Nyando Sub-county, Seme and Kisumu East.

a wide range of financial institutions (banks, insurance companies, and corporations), most of the credit facilities and insurance services available to farmers require them to use their title deeds as collateral and incur high interest rates, discouraging the use of such financial products and even farmers' engagement in agri-business.

Agricultural value chain commodities in Kisumu



Climate change-related risks and vulnerabilities

Climate change and variability: historic and future trends

Kisumu County has a relatively warm and humid climate all year round with mean annual temperatures being predominantly in the range of 21°C to 23°C in most parts of the county, except for a few pockets in the south and east where mean annual temperatures are below 21°C and a few pockets in the central parts where mean annual temperatures are between 23°C and 24°C. The county has two rainfall seasons, the first from March to May and the second from November to December. Mean annual rainfall in the county is mostly in the range of 1200 to 1500mm. However some areas do receive mean annual rainfall of above 1500mm. The climate and weather of Kisumu is largely modified by its location on the shore of the Winam Gulf of Lake Victoria, which results in high humidity all year round.

Analysis of temperature trends in the county over 25 years (1980 to 2005), showed that although mean second season temperatures have remained relatively constant, there has been a significant increase of approximately 0.5°C in mean first season temperatures. Average annual rainfall, measured over a 35-year period (1980-2015), has also increased in both seasons. However the increase has been more pronounced in the second season. The increase in second season rainfall has been accompanied by an increase in the length of the growing season, and a slight decrease in the number of heat stress days. The first season on the other hand has not had a significant change in season length, drought stress or the number of heat stress days but has experienced a reduction in flood risk.

Looking ahead to the period 2021-2065, climate projections based on two representative concentration pathways (RCPs[34]) indicate that under both scenarios there is expected to be a moderate decrease in the length of both growing seasons as well as a large backward shift in the start of the second growing season by as much as 50 days from a historical start day at 240 to as late as day 295 under RCP8.5. Heat stress is also expected to increase significantly under both scenarios, the number of days with a mean temperature above 35°C in the second season being particularly affected and expected to rise from an historical average of just under 10 days to over 15 days under the conservative emissions scenario and 20 days under the high emissions scenario. These changes represent an increase in the number of heat stressed days by approximately 50% and 100% respectively. Under the low emissions scenario rainfall quantity and intensity are expected to increase along with an increase in flood risk[35] in both the first and second season; however under the high emissions scenario the projection is for an overall decrease in the amount and intensity of rainfall in both seasons. Although the projections of future climate change under the two GHG emissions scenarios show some differences, both indicate the likelihood of significant changes in the weather and climate of the county with probable impacts on crop and livestock production.

Climate Perceptions by the farmers

The effects of climate change and variability are already faced by most farmers in Kisumu County. They report overall poor distribution and higher variability and unpredictability of rains (including late onset[36] of rains in 2016 and early onset in 2017), affecting the plants' growing season, as well as increased cases of floods in Miwani and Ombei, the Nyando basin, the Kano plains, the lower Nyakach areas, and Kisumu East. "Having been a farmer all my life, I have seen first-hand how climate variability has affected the maize production, we used to have two robust seasons every year now we have one and have resulted to planting drought tolerant crops such as sorghum[37]." Higher temperatures and heat stress, prolonged dry spell in areas of Nyakach, Seme, Nyando, stronger winds, have also become more regular, in their opinion. Soil degradation, drying of wells and rivers, and reduction in water volumes are some of the many environmental challenges that constantly hit already vulnerable farmers (GoK 2014). All these combined have brought about new weeds, pests and diseases, have reduced sizes of pastures and spawned conflicts over land resources[38], caused crop failures, and increased food insecurity and even costs of living in the area.

34 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.

35 Indicated by the maximum 5-day running average precipitation in mm/day

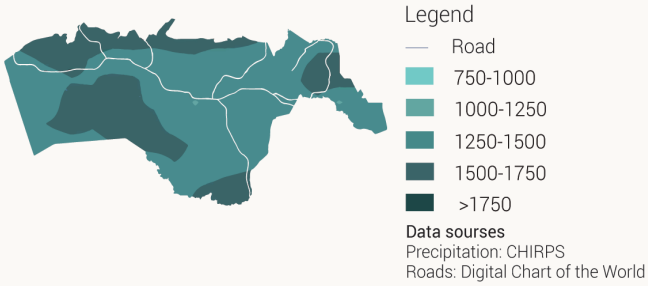
36 More exactly, it refers to the long rains (March-April-May) and their late onset at the end of March and early onset in mid-February.

37 A testimonial from a sorghum farmer in Stopamba Nyakach Sub county.

38 Sporadic cattle rustling along the Nyakach-Nandi border and also the disputed boundary have resulted to conflicts between the Kalenjin and Luo community especially due to the discovery of potential oil deposits in Nyakach and Kericho.

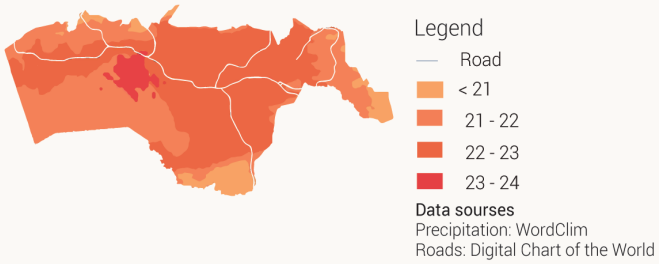
Past and future impacts of climate hazards in Kisumu

Historical annual mean precipitation (mm/year)



Data sourses
Precipitation: CHIRPS
Roads: Digital Chart of the World

Historical annual mean temperature (°C)



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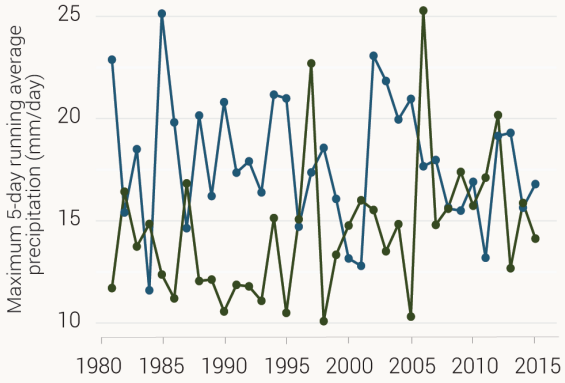
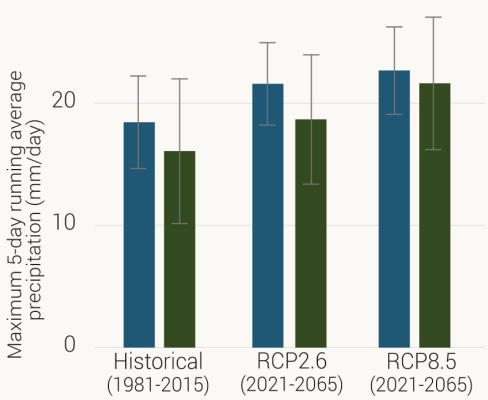
Flood hazards

Historical extreme flood events

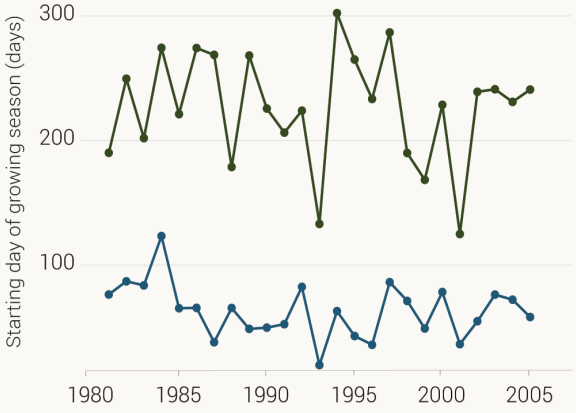


Historical and expected extreme flood events

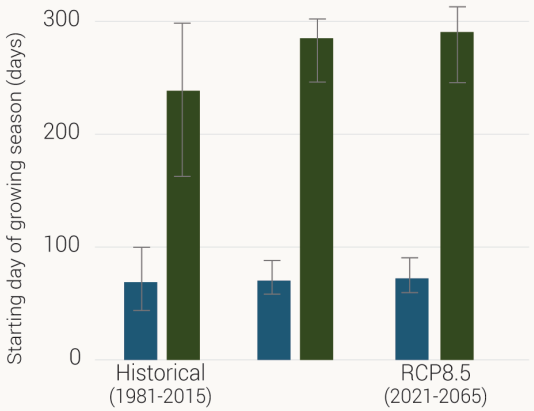


Uncertainity in the start of growing season hazards

Historical uncertainity in the start of growing season stress events



Historical and expected uncertainity in the start of growing season stress events



January - June July - December

Climate vulnerabilities across agriculture value chain commodities

Farmers in Kisumu County are heavily reliant on rain fed agriculture and thus extremely vulnerable to climate change and variability. The frequency and severity of climate shocks such as drought, floods, and heat stress; the uncertainty related to the start of the growing season and the duration of the growing periods affect key value chains and farmer groups in differentiated ways, as discussed in the sub-sections below.

Leafy Cowpea

Uncertainty of season (onset and duration) affects land preparation and management and subsequently changes the growing conditions of the crop. Cowpea is heat-tolerant, yet germination rates can be low if soil moisture is insufficient at early stages of the planting cycle, causing low crop productivity. Extreme rainfall conditions are also detrimental, as the crop cannot survive in waterlogged soils. In Kisumu County, soils are susceptible to erosion and soil nutrients leaching, which can greatly affect the overall crop's growth. The low-lying areas of Kano plains, Lower Nyakach and some parts in Muhoroni are more flood prone than the highland areas of Nyakach Koguta and the midland areas of Maseno.

Crop rotting during storage or transportation is also common, if moisture levels are too high. This renders low-quality marketing output and lower prices for the farmers, especially under conditions where smallholders' bargaining power is undermined by intermediaries, in the absence of established associations and cooperatives.

Sorghum

Apart from decreases in the length of the growing season[39] that trigger pre-harvest sprouting, extreme/increased rainfall is particularly disturbing for sorghum. This leads to soil erosion and water logging, affecting both crop growth and the infrastructure for transportation of inputs (seeds) and outputs to the market. Re-used seeds are likely to have increased moisture content, which renders them unproductive. The black cotton soils in the low-lying areas of Kano (Nyando Sub-county) are very prone to waterlogging (compared to loam soils), as they hold moisture for long. This leads to poor germination of the seeds/planting material, rotting of the planting materials, and also increases higher demand and costs for labour and even mechanization. Given the high moisture content, the incidence of aflatoxin in the post-harvest stage increases, as the likelihood of post-harvest pests and diseases is higher. Lower quality and quantity of sorghum drives prices down, affecting sales and incomes[40]. Children are particularly affected by crop failure and post-harvest losses, as sorghum is a key staple food for the population and a main nutrition source for most households.

Cassava

Erratic seasonal rainfall and failure of grain crops have spurred the interest of many farmers in looking into cassava production, as a viable alternative to sustaining their livelihoods. Cassava has high risk aversion potential, being able to grow under harsh soil and weather conditions.

However, the uncertainty of season (onset and duration) affects land use planning, preparation, and seed supply, with spill-over consequences on the other value chain stages. Moreover, extreme rainfall may have detrimental effects on land preparation due to soil erosion, but also on labour needs for weeding activities, as rains increase the frequency and quantity of weeds that compete with the crop for soil nutrients. The farmers in the low-lying areas of the Kano Plains, Nyando, and lower Nyakach are more vulnerable due to the risk of flooding than the farmers in the highlands of Nyakach Koguta, Kajulu and the midlands in Maseno. Heavy rainfall also affects the accessibility of the already poor road network, limiting the availability of seeds and thus driving prices higher. Delivery of extension services is also affected, as officers are unable to physically reach the farmers on time.

In the post-harvest stage, incidences of moulding are quite frequent, requiring additional time for cleaning and drying of harvest. On the market, the competition between cassava crop and other crops with higher tolerance to excess rains (such as arrow roots) is high, reducing sales of cassava and hence affecting farm incomes. Some farmers are organized into groups (e.g. Kamicha Kabondo) and their vulnerability to fluctuating demand and prices is relatively lower, as they engage in collective bargaining and promotional activities during field days.

39 This is especially felt in very dry areas such as Kusa. In areas around Seme, the youth have started switching to alternative enterprise such as fishing, to reduce their dependence on climate-vulnerable crops.

40 This is particularly affecting women, who are the main growers of the crop in the County.

Chicken (local)

Increased temperatures trigger the incidence of Newcastle disease and infectious bursal disease (Gumboro disease), leading to declines in production and/or stock loss. Heavy rainfall causes significant damages to poultry housing structures and storage facilities, bringing about fowl typhoid, and coccidiosis, which increase the demand for and expenditures on vaccination and treatment. Such conditions are particularly common in the low-lying areas of Nyando and the Kano plains due to the frequency of flooding, hence increased incidences of diseases.

Farmers linked to a cooperative (such as KICOPE) are more likely to acquire vaccination and feeds since they access the services as a group, while procure additional water, engage in water-harvesting techniques, and purchase and/or store supplementary feed for the poultry. In general, access to advisory services is challenged by poor road conditions in times of extreme rainfall, but also by reduced office hours of extension agents/ advisors, due to low human and financial capacity.

As with other agricultural products, low quality meat and eggs result to low prices and incomes. The absence of any form of association also limits the farmers' ability to sell their goods. Reliance on social media, television, and radio for obtaining market information becomes the sole option for many.

Adaptation to climate change and variability

On-farm adaptation practices

In response to some of the previously mentioned challenges, farmers in Kisumu County have come up with a wide range of on-farm adaptation measures to increase the resilience of their production systems and livelihoods to a changing, unpredictable climate. These strategies include soil management and conservation practices (staggered cropping, green manure, composting, ploughing back of the organic material), promotion of drought-tolerant varieties[41] of traditional crops (sorghum, cassava, green grams sweet potatoes), intercropping with legumes (maize and sorghum in Stopamba, Nyakach), and also water conversation practices (rainwater harvesting and storage to enable use during the dry spell, water pans, and irrigation infrastructure); smallholder irrigation schemes are currently extended over a total of 6,000 ha of land. According to ASDSP household report, the main adaptation strategies used were; tree planting (31%), changing the crop type (27%), practising staggered cropping (19%), and water harvesting (12%). However, male and youth headed[42] households tend to practice tree planting more while women do staggered cropping and changing of crop types.

In addition, to prevent post-harvest grain loss that occurs due to inadequate harvest times, insufficient drying of crop, or inadequate handling, farmers now benefit from post-harvest storage technologies (PICS improved storage bag, use of Actellic Super Dust) that allow storage of grain for longer periods (often for several months), until selling becomes profitable (One Acre Fund 2014). The use of PICS bags has helped lower pesticides usage, ensure higher quality and quantity of stored grain, and facilitate access to higher market prices (One Acre fund 2014). Many farmers also apply traditional knowledge to cope with crop stresses; for instance, they use ash as a natural insecticide to fight against pests and diseases in grains and store their produce on timber platforms above the ground, to prevent absorption of moisture.

For livestock farmers, common adaptation measures include: fodder conservation, zero grazing, drought-tolerant feeds (e.g. *Brachiaria*), pest control through crush pens, and vaccination[43]. Through breeding programmes led by the International Livestock Research Institute (ILRI), new climate resilient breeds of sheep and goats[44] have been introduced and researchers now engage farmers in practical trainings on improved animal husbandry practices and on using simple information management tools to monitor the impacts of such practices.

Agroforestry is also popular in the County, especially in the Lower Nyando Valley, where alleys of maize, sorghum, and other crops are sandwiched between rows of multi-purpose trees (*Grevillea robusta* and *Gliricidia sepium*)[45] that stabilize and enrich the soil. Demand for trees has increased the number of seed

41 KALRO has been at the forefront when it comes to the development and promotion of varieties adapted to climatic risks, such as the WEMA maize and Sorghum KARI Mtama-4.

42 According to the survey carried out by ASDSP, youth headed households are categorized as male and female between 18 to 35 years who head the households.

43 The vaccines are subsidized by the DVS through a revolving fund (micro credit scheme for resource poor farmers that enables them to finance the vaccination activities), whereby animal vaccines cost KES20, while dog vaccination is free.

44 The cross breed is between the small east African goat and the Galla goat which will be referred to as the Nyando Composite goat. It is resilient to the prevailing climate conditions and produces more milk than the local breeds.http://www.nation.co.ke/business/seedsofgold/New-goat-breed-promises-high-yields/2301238-2725846-yp3k8vz/index.html

45 Since 2011, about 23,500 multipurpose trees have been planted in Nyando and the local community has established a two acre demonstration woodlot.https://ccafs.cgiar.org/blog/photo-story-responding-climate-related-risks-address-food-insecurity-nyando-kenya#.WYAgzoSGPmE

nurseries (currently at 22)[46], offering great potential to improve the forest cover[47], but also to enhance women's livelihoods, as they own more than half of the nurseries in Lower Nyando. Bee keeping has been used as a key diversification activity, especially by farmers whose crops or livestock are very exposed to climatic risks. Through Phase II of the Lake Victoria Environmental Management Project (LVEMP II), bee keeping has been introduced as an income-generating activity among six farmer groups in Kajulu areas. This project offers financial support to these farmer groups. Through the asset financed solar irrigation pumps for small holder farmers' project various agro dealers are engaged in the distribution of solar powered irrigation[48] pumps for horticultural farmers. This helps them to reduce reliance on fossil fuels and maximise on their profit margins.

Off-farm adaptation practices

In Kisumu County, off-farm services such as early warning systems (EWS), insurance, extension and training, credit, storage facilities, and market information are facilitated by governmental institutions, the private sector (private financial institutions, agro dealers), and cooperatives.

Under the guidance of experts, participatory scenario planning (PSP) meetings are organized every season, bringing together key local stakeholders. Meteorological experts then interpret the scientific and traditional knowledge for farmers and inform them on long term planning. For instance, KMD provides county specific weekly forecasts, send to trained farmers and fishermen via SMS, Department of Agriculture provides information on water requirements of specific crops and types of seeds suitable for each season, the Department of Livestock offers marketing advice e.g. market value and prices, while the Department of Veterinary services provides advisory on the management of expected diseases and pests. All these information is discussed during the meetings and then compiled into a simple, concise version (brochures in local languages, leaflets) for a wider public, which is then broadcasted through local radio stations. Such PSPs are facilitated by Care Kenya and the Department of Green Energy and Climate Change (DGECC), through the ASDSP.

Early Warning Systems are managed by KMD. Through pamphlets and brochures, KMD produces recommendations on suggested planting and livestock migration times and locations based on drought and flood projections. As the majority of the population has radio access, seasonal forecasts delivered through such a channel become available to a wide public (especially youth). Climate-related information is also facilitated by government extension staff, partners, faith-based organizations, and non-government organizations (NGOs). For instance, farmers in Stopamba (Lower Nyakach), a climate smart village (CSV) set up by the CGIAR Research Programme on Climate Change, Agriculture, and Food Security (CCAFS), now receive weather advisories from the KMD directly on their mobile phones, which makes the information readily available to them for use in their daily agricultural activities.

Agricultural extension officers also provide trainings and on-farm demonstrations on sustainable land management practices such as intercropping, conservation agriculture, terracing, water harvesting, composting, and agro-ecological crop selection. Many male- and female-headed households rely on traditional indigenous knowledge to plan their agricultural activities (GoK, 2014). Most farmers have organized themselves into farmer groups especially based on their crop and/or livestock farming systems (affiliated to Friends of Katuk Odeyo [FOKO][49]), to establish cereal banks e.g. the off-farm sorghum storage facility set up in the NCPB warehouse in Kisumu city. This service[50] allows farmers to cushion themselves from possible postharvest losses caused by poor grain handling.

Information regarding markets and marketing channels is weak and insufficiently available throughout the County and across value chains. The most well-developed and better organized cooperatives are KICOPE and KIPOTRA, who offer market information

46 https://ccafs.cgiar.org/climate-smart-villages#.WX735oSGN1s

47 The County's forest cover is currently at 0.4% of the total land area. To help expand the forested area, apart from agroforestry, farmers also engage in the establishment and maintenance of woodlots, with support from KEFRI in Maseno.

48 The pump is called sunflower, an initiative by the Future Pump partnering with Kenya Equity Bank to make the product available to consumers through consumer financing. https://poweringag.org/innovators/sunflower-pump-asset-financed-solar-irrigation-pumps-smallholder-farmersblog/photo-story-responding-climate-related-risks-address-food-insecurity-nyando-kenya#.WYAgzoSGPmE

49 Named after a popular Katuk Odeyo gulley, FOKO was initiated in 2001 as a self-help group and now. It now has 32 affiliated groups (each with 10-30 members) and engages in sustainable agriculture, community reproductive health, community-based natural resource management, and capacity building of members in basketry and table banking (innovation fund).

50 This paid for service (warehouse receipt system) allows the farmers to deposit the receipts with banks (e.g. Equity Bank) for cash loans or credit.

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

Cassava

	Provision of seeds and other inputs	On-Farm production	Harvesting storage and processing	Product marketing
Extreme rainfall	Affects availability and access to seeds/planting material due to impassable roads; Limited off farm services; Interferes with cassava breeding activities	Hinders land preparation; Rotting of cassava cuttings; Increased cost of production due to increased frequency of weeding; Leaching of soil nutrients due to soil erosion from water run off	Molding due to wet conditions and dampness; increases time for storage; Hinder transportation to the markets; Low rate of processing	Limits promotion activities e.g. field days; Stiff competition from moisture tolerant crops hereby reduced prices and sales
Magnitude of impact	Major	Major	Major	Moderate
Farmers' current strategies to cope with the risks	Housing certified bulking plots;-Farmer to farmer trainings; Continuous research to get clean and certified seeds while using own cassava cuttings	Relying on weather advisories; Researching of tolerant/tolerant varieties;-Digging farrows; planting varieties that form canopy faster	Lobbying for processing machines;-Farmers lobby for infrastructure improvement; Maintaining the available road network; Value addition to increase profit gains	Improving the market centers; Promotion through local media channels; Provision of warehouses; Value addition through packaging; Forming strong cooperatives
Other potential options to increase farmers' adaptive capacity	Bulking plots; Trainings (farmer groups/ToTs);-Equipping existing institutions with modern technologies	Digging more drainage channels; Getting clean, tolerant and early maturing varieties; Encouraging water harvesting technologies e.g. water pans	Building better storage facilities; capacity building farmers on value addition activities that increase the shelf life of products	Strengthening of existing marketing channels; Promotion through exhibitions and digital media; improving road networks and transport equipment
Uncertainty of seasons (onset and duration)	Uncertainty in time of seed supply; lack of proper preparation of farmers	Delays land preparation and planting; uncertainty in weeding, spraying and harvesting	Affects planning of the processing, there is uncertainty in the processing activity	Uncertainty in marketing activities; price fluctuations; unbalanced demand and supply
Magnitude of impact	Moderate	Major	Minor	Moderate
Farmers' current strategies to cope with the risks	Farmers bulking seeds to wait for the right time; reliance on weather advisories	Relying on weather advisories; mechanization; planting drought-tolerant varieties; planting early /medium maturing varieties; planting certified and clean seeds; continuous monitoring; supplemental irrigation	Exchange programs with others (collaboration)-farmer to farmer learning	Continuous field schools/days; organising for slides and exhibitions involving the media; starting cooperatives; organize farmer groups; market research/survey
Other potential options to increase farmers' adaptive capacity	Seed bulking;-Intensive extension services (farmer to farmer and service providers);Equip and modernize existing facilities that supply inputs	Strengthening early warning systems on cropping season quality; Upgrade to Farm Mechanization; continuous research on moisture/drought tolerant varieties; training farmers on the need to plant improved varieties	Building modern storage facilities and build better roads to link farmers to buyers /consumers; procure processing machinery and promote value addition to increase income for farmers	Strengthen existing cooperatives by improving linkages with value chain actors and markets; Link farmer groups to farmer unions to support access to market information

Chicken (local)

	Provision of inputs	On-Farm production	Harvesting storage and processing	Product marketing
Extreme rainfall	Mobility of extension service providers affected negatively due to flooded roads; Destruction of housing/structure which increases expenditure due to maintenance costs ; Increased costs for drugs for disease control	More cleaning required; Scarcity of feed; frequent changing of the bedding to avoid dampness; scarcity of feeds due to impassable roads; forage growth is affected by flooding	Difficulty in market accessibility and feeds availability due to impassable roads; farmers' households result to home slaughtering	When accessibility is affected, sales are low because of market penetration; reduced supply/ high demand hence high prices; limited access to market centres
Magnitude of impact	Moderate	Moderate	Major	Minor
Farmers' current strategies to cope with the risks	Trainer of trainers to assist farmers in provision of advisory services; Working in collaboration with stakeholders; Capacity building of chicken farmers on proper poultry structures	Sponsored vaccination programmes; Advice on proper hygiene practices given by service providers; On-farm feed formulation using locally available resources	Capacity building on proper handling during transportation; Construction of proper storage facilities i.e. horticultural structures in Kisumu	Value addition by dressing, freezing and proper packaging; Dissemination of information on the prevailing market prices by the extension service providers
Other potential options to increase farmers' adaptive capacity	Purchase of four wheel drive vehicles for extension services; Offering financial assistance/support the poor; provision of feeds, disinfectants at subsidized prices	Availability of vaccination at no cost; Increased capacity building on poultry management; training of farmers on effective climate adaptation strategies	Establishment of local/homemade processing facilities; Improvement of road networks; Capacity building and sensitization on poultry enterprise development	Promote E-marketing platforms; Market products in groups and exporters as this improves collective bargaining power of farmers; Develop a farmer communication platform
Increase in temperature	increased costs of production due to increased supply of drugs ,supplement feeds etc	Increased labor due to maintenance of the housing structures, increased farm activities (e.g. vaccination); more feeding and water intake	Poor quality of the meat and eggs	Price fluctuations due to poor quality of meat and eggs; economic losses
Magnitude of impact	Moderate	Major		Minor
Farmers' current strategies to cope with the risks	Extension services offered during early hours of the day; Capacity building for the recommended housing plans using locally available materials; Farmers aligning themselves in groups and cooperatives to obtain input at subsidized cost on credit	Well-constructed structures with proper ventilation and hygienic; Farmers aligning themselves in groups and cooperatives to get knowledge on on-farm feed formulation	Capacity building on proper poultry management practices-farmer to farmer learning	Sell to middlemen directly from the farm to reduce transportation costs to the market
Other potential options to increase farmers' adaptive capacity	Training of more trainer of trainers; Establishment of revolving fund so as farmers can access funds for poultry structures at lower interest rates	Kenya veterinary vaccines production institute (KEVEVAPI) to regulate vaccination activities ;integration of farmers' knowledge through establishing local industries that manufacture local feeds	Provision of vehicles for easier transportation of chicken; build slaughtering houses and refrigerated storage facilities	Price standardization; Promote contract farming;

Cowpea (leafy)

	Provision of seeds and other inputs	On-farm production	Harvesting storage and processing	Product marketing
Increased/Extreme rainfall	Topsoil is washed away by the floods leaving bare land (erosion); seeds access is a problem during long rains; less man power	Heavy mud delays land preparation the seeds will be washed away or rot; increase in incidence of weeds; delay in crop cycle	Delay in collection; middlemen will take advantage with cheap prices; rotting; incidence of pests and diseases; farmers opt to sell at low prices to reduce product loss	Product sells at low price
Magnitude of impact	Major	Severe	Major	Moderate
Farmers' current strategies to cope with the risks	Building of dykes to prevent the overflow during floods; timely planting; conservation agriculture i.e. use of herbicides	Early land preparation before the onset of rains; early planting and opening of canals to release water; herbicide application	Proper timing and avoid a lot of rain during collection; formatting of farmer cooperative and improving road for transporting product to the market; construction of proper storage facilities i.e. horticultural structures in Kisumu	Formatting of farmer cooperatives to increase bargaining power and link farmers to buyers; formation of cooperative to make farmers to buyers and also value addition to the product; proper timing
Other potential options to increase farmers' adaptive capacity	Building of gabions; the county government should source the seeds to the cooperatives and farmers; the county government should promote affordable prices at the right time	Provision of machinery at affordable prices; making canal to release excess water by the government; the county government should give the capacity building to farmers	Provision of storage facilities to the farmers; rural roads well-maintained; the government should promote Kenya farmer association with finance to ensure there is improvement in agriculture	Farmers select the marketing committee to make marketing research; form cooperatives that link the sellers to buyers via media; training to farmers in the importance of early planting
Uncertainty of seasons (onset and duration)	Farmers will wait for rain to start land preparation; poor planning for seed supply; lack of labour	Late planting leads to low yield on farm produce; late weeding	Late collection on farm produce; few bulking (low produce collected)	Increased middlemen; low price for the produce; poor sales on the produce; low income
Magnitude of impact	Moderate	Major	Moderate	Major
Farmers' current strategies to cope with the risks	Buying of water tanks by the individual farmer groups; changing the seed variety that can suite the situation; proper planning i.e. work the portion you can manage	Proper timing; acquiring knowledge from experts; practice moisture conservation strategies like mulching	Timely planting; formation of farmer groups to help reduce the transportation cost; increasing the value of produce to incur high cost	Formation of farmer groups (networking). contract farming; formation of farmer groups; value addition on the product
Other potential options to increase farmers' adaptive capacity	Provision of grunts to farmers to promote farming, purchase certified seeds; and farm equipment	Meteorologist should provide farmer with relevant weather information; train farmers on proper agricultural practices and methods of conserving moisture on the farm i.e. organic mulching	Farmer groups should work collectively; training on the ways of preserving the farm produce and even providing the weighing machine	Linking farmers to buyers via telephone (e-marketing); formation of cooperatives to help farmers in marketing; use local radio station to advertise the produces

Sorghum

	Provision of seeds and other inputs	On-Farm production	Harvesting storage and processing	Product marketing
Increased/Extreme rainfall	Increased cost of labour; difficulty in accessing the seeds; the seeds to be re-used might be affected by high moisture	Surface runoff (erosion); increased cost and time of land preparation; poor germination of seeds/planting material; damage of the crop in the field due to rotting	Damaged product quality and increased duration of the exercise; high chances of aflatoxin due to high moisture content in the atmosphere; possible leakage and pest invasion	Reduced price of the crop due to reduced quality; poor communication and accessibility to markets; increased price of the commodity
Magnitude of impact	Major	Major	Major	Major
Farmers' current strategies to cope with the risks	Continue reuse of the previous seeds; drainage and conservation measure	Mechanization and reduced tillage; drainage and conservation measures; use of lodge-tolerant varieties	Some farmers raised their stores above the ground; channelling rain-off away from the store	Store the produce and wait the price to improve; organized farmer groups
Other potential options to increase farmers' adaptive capacity	Mechanization of operations; use of certified planting materials that can tolerate high/extreme rainfall; capacity building on sustainable soil and water conservation; drainage	Capacity building on sustainable agriculture; channelling of drainage systems; planting lodge-tolerant varieties	Initiate use indoor drying machinery and structures; promotion of hermetic storage e.g. pic bags, material silos, grain bags; encourage central warehouse receipt system	Encourage formation of functional farmer groups, SACCOs; encourage use of IT e.g. SMS, webpages; establish farmer assistance and traders network; importation from other regions; keep enough stock for traders
Decrease in length of growing season	Land more difficult to work on; it either increase labour if the season starts late	Possible repeat of land preparation; change of variety if season starts late; reduction in time spent during harvesting activities	Decrease in harvesting activities since the expected yield is low; damage to stored product from the pests	Possible reduced quality and quantity hence high pricing; low quantities weakens the link; high selling price
Magnitude of impact	Moderate	Major	Moderate	Moderate
Farmers' current strategies to cope with the risks	Prepare land immediately after the previous season	Reduce the cultivated land area and their reliance on weather forecast both indigenous and scientific; change of variety	The chaff is used as animal feed; use pesticides to control postharvest pests	Importation from other areas by the millers; get local buyers
Other potential options to increase farmers' adaptive capacity	Mechanisation of land preparation; promotion of drought tolerant/escaping planting materials; develop seedling nurseries	Mechanization programmes. Improve access of farmers to weather forecasts; promotion of soil and water conservation measures change risks	Improve grading of the product; mix with other ingredients to make livestock feeds; carbonise to use as fuel; promotion of hermetic storage	Storing in excess; continued use of the local buyers; import from other areas especially the millers

to their members and facilitate them access to buyers. Farmers outside such groups remain deprived of such marketing opportunities and their incomes are visibly affected.

Insurances for crops, livestock, and fisheries are underutilized services in the County. They are facilitated by the Kenya Commercial Bank (KCB) and Equity Bank, which offer financial insurances against floods, fire, drought, excessive rainfall, pests and diseases, frost, and hailstorms. However, very few farmers are aware of the availability of such instruments and even fewer are able to afford[51] them since they do not have enough capital to cover the agricultural insurance. Financial institutions such as banks and the Agricultural Finance Corporation (AFC) offer agricultural credits and loans, especially for horticulture, beekeeping, dairy goat and cattle value chains, at interest rates that vary between 10% for farmers and 15% for agribusinesses. Yet most products are unsuitable for those farmers who cannot demonstrate ownership of the land or credits and loans history.

Policies and Programmes

Policies, programmes, strategies and action plans are key considerations for agriculture decision making, since they affect actions and outcomes related to resource use. Kisumu County implements a wide range of policies ranging from the international conventions, to national statutes to the local policies[52]. These policies are implemented by key institution in the line ministry of the specific policies, the decentralization of the decision making is a pro in the effective implementation of these policies.

Kenya is a signatory to United Nations Framework Convention on Climate Change (UNFCCC) since 2005 and the DGECC is commissioned to ensure that County-level operations are aligned with the commitments framed under the UNFCCC. DGECC ensures alignment through the institution of the low carbon, it engages in advocacy and awareness in the adaptation towards the green energy and the reduction of the pollution to reduce on the greenhouse gas emission[53]. However, some of the challenges faced in the implementation of this policy is the inaccessibility of the funds from the treasury as the recurrent budget is minimal thus curtailing the implementation of the policy.

The country's development programme, Kenya Vision 2030, identifies agriculture as one of the main sectors to deliver the 10% annual economic growth rate envisaged under the economic pillar. Key to this growth, is the transformation of smallholder agriculture from subsistence to an innovative, commercially oriented and modern agricultural sector. This has been achieved in Kisumu through, production of enough raw materials for the industries and conserving the agricultural base. Kisumu County is also a beneficiary to the Kenya Climate Smart Agriculture Project (KCSAP) that will provide opportunities for upscaling climate smart agricultural activities, strengthening climate smart agricultural research and seed system, supporting agro-weather, market, climate, and advisory services, project coordination and management.

The Agriculture Sector Development Strategy (ASDS) (2010-2020) places strong emphasis on progressively reducing unemployment and poverty (GoK, 2010), which are instrumental for a food-secure and prosperous nation. The overall development and growth of the sector is anchored on two strategic pillars: (i) increase of productivity, commercialization and competitiveness of agricultural commodities and enterprises and (ii) development and management of key factors of production. All County governments (including Kisumu) align their operations to this strategy.

The Crops Act from 2013 seeks to accelerate agriculture sector growth and development, enhance productivity and incomes of farmers and the rural population, to improve investment climate and efficiency of agribusiness, and to promote agricultural export crops. At County level, the DA is responsible for making sure that the objectives outlined in the Act are actively promoted in local strategies and on-field interventions.

The Climate Change Act provides a framework for funding mitigation and adaptation activities at national and county level. This is through the climate change fund that provides the mechanisms for funding the priority climate change interventions through grants in research, provide incentives for the opportunities geared towards climate change mitigation .It was ratified by national legislature in 2016, following which a number of County-level stakeholder meetings have been taking place to enable an environment for implementation at local level.

The Environmental Management and Coordination Act was formulated in 1999 and amended in 2015, to include climate change considerations on the agenda. It guides ministries in the endeavour to consider climate change mitigation measures in their actions and budgets, requiring the establishment of environmental departments or designated officers in each County. In Kisumu, this is achieved through Climate Change Secretariat that hold stakeholders' meetings on integrating the climate change

51 Most insurers would want farmers to provide collateral (land, premium subsidies) as part of a safety net

52 The local policies are however in draft form. The international and the national laws are domesticated to meet the needs of the county.

53 Through the community climate change committee in each of the sub counties. Each village has a climate change resource person.

issues in the various departments in the county. However, there is need for adequate collaboration and coordination

The Forest Act of 2005 embodies several innovative solutions to rehabilitate degraded sites and support national tree planting efforts, including a strong emphasis on partnerships and the engagement of local communities. However this has not fallen through due to lack of community participation , inadequate collaboration with the county government, limited funding that hinders their interventions.

CAP 364 Disease control is an act of parliament that provides for the prohibition and the regulation of importation under section 8 of the subsidiary legislation. This subsidiary legislation informs the public of the notifiable disease (Section 2). It provides for Animal Diseases (Compulsory Rinderpest Vaccination) Rules of 1964. Where, all cattle shall be immunized by a rinderpest vaccine approved by the Director of Veterinary Services and immunity shall be maintained by repeated vaccinations as considered necessary by the Director of Veterinary Services. The animal vaccination program is spread across the county through subsidized vaccination. The county government achieves through the revolving fund. Meat Control Cap 356 is also an act of parliament that provides for licensing, control and regulation of slaughterhouses and for premises where meat is processed in any manner for human consumption; health, sanitary and hygiene standard in slaughter houses and meat processing premises: packing and labelling of meat; storage and transport of meat. Other very key legal considerations include National Livestock Policy 2008, National Irrigation Policy 2012 and Kenya Forest Policy 2015,

In addition to these policies, several programs and on-field operations aimed at addressing climate vulnerability have been put in place through the collaboration of local, international, public and private actors. Some of them are discussed below.

The Energising Development Programme (EnDEV)[56] is a global initiative to expand access of rural households to clean energy, with co-financing from the governments of Netherlands, Germany, Australia, the United Kingdom, Norway, and Switzerland. In Kenya, the initiative was launched in 2006 under the leadership of the German Development Agency (GIZ), with the aim to encourage wider uptake of improved cooking stoves, as part of a larger endeavour to promote private sector engagement in agriculture. The programme supports the development of technical, commercial, and organizational capacities of the actors involved in producing, marketing and installing improved cooking stoves, with a focus on promotion of entrepreneurship. Apart from the stoves, EnDEV Kenya also promotes access to clean sources of lighting and basic electricity services (such as mobile phone charging). The programme also explores the technological and economic viability of power generation using biogas from agricultural waste.

The Pambazuko New Dawn Lake Victoria project is a multi-partner[57] project that aims to improve the resilience of vulnerable communities through the integration of reproductive health and rights into sustainable development programming. The project targets vulnerable communities in Awasi and Nyangoma locations in Nyando Sub-County and is implemented through Population Health and Environment (PHE) an integrated that recognizes relationship in population[58], health and population , approach by the Danish Family Planning Association (DFPA) and the Danish International Development Agency (DANIDA). The activities developed integrate health and environmental conservation initiatives to seek synergies for greater conservation and human welfare outcomes. The project achieves this through clustering groups and individual members to groups to work through model farms and common interest groups for ease knowledge sharing, capacity building and joint initiatives, mobilizing and lobbying the stakeholders from the three sectors to work in synergy for better coordination. Some of the impacts/ outcomes of the project include, realization of the interdependence on PHE by the beneficiary communities, greater appreciation for the need for environmental conservation in view for its importance to health and sustainable development.

Scaling up Climate smart village models in East Africa project builds up on the previous CCAFS CSVs. It is a partnership between research and development organizations and the Nyando rural community. They that have developed Climate-Smart Villages (CSVs) model to test local actions that ensure food security, promote adaptation and build resilience to climatic stresses in Nyakach Sub County. This includes testing of drought tolerant crop varieties and sustainable small ruminant breeding program using participatory community approaches[59], the project promotes increased meat and milk production of small ruminants, with the aim to increase incomes of smallholder farmers and pastoral herders. Up to now, project researchers have enabled the introduction of Galla goats and red Maasai sheep crossed with Dorper sheep in the seven villages in Nyakach Sub

56 *By mid-2016 this project had more than 5 million beneficiaries with access to improved cooking facilities and 180,000 people with had access to electric power due to the small solar power systems. It is estimated that 640,000 tons of CO2 was prevented saving more than 0.5 million tons of firewood.*

57 *Partners include: Community Rehabilitation and Environmental Protection (CREP) Programme, Family Health Options Kenya (FHOK), Vi Agroforestry, and Osienala*

58 *It supports coordination and collaboration in these three areas as these three areas are interrelates and interdependent*

59 *Establishment of breeding programs*

County and have offered farmer trainings on improved animal husbandry practices such as selective mating. The organization of the households into CSVs provides a great opportunity for capacity development which should have a strong component of engaging the youth, and the development of a selection and breed improvement.

Other projects related to agriculture and climate change implemented by the Kisumu county government through the line ministries[60] include, among others: the "Clean seed" programme to encourage the use of certified planting material, The "Rehabilitation of the irrigation schemes" project, the "Micro irrigation" Project, The "Excavation of water pans to conserve water and promote fertilizer use" Project, the Project for restocking of the fish ponds, The "Improvement of the local Chicken" Project, The "Apiculture" project, etc.

Governance, institutional resources, and capacity

In agriculture, the role of institutions can be related to the design of policies and investment frameworks, knowledge development and sharing, technological development or the delivery of financial and non-financial incentives for agricultural investments (FAO, 2010). In Kisumu County, there are several institutions[61] actively involved in climate-related issues, ranging from government actors and NGOs, to private sector, community based organizations (CBOs) and cooperatives.

KALRO, a governmental organization operating at the County level, is responsible for the promotion and dissemination of knowledge and technological development among relevant stakeholders. Together with its partners[62], the institution supports the development of trials and on-farm demonstration plots for sustainable land and water management and crop and livestock production practices, all these targeted at farmers and staff in relevant local departments. In Kisumu, KALRO Kibos focuses its research on medium-altitude crop varieties of maize, sorghum, cassava, and horticulture. Improved crop varieties, such as striga-tolerant maize (Maize GAF 4) and Sorghum KARI Mtama 4, were developed by KALRO Kibos. However, its operational capacity is constrained by insufficient funding and infrastructural support (well-equipped laboratories, high-tech seed storage banks) to carry out the planned interventions. KMD generates seasonal forecasts based on analysis of climate data and stakeholders' workshops, where indigenous weather forecasters and relevant departments are present. Through PSP, experts develop an information dissemination plan that is usually implemented through the ASDSP Environmental Resilience Office. KMD downscales national forecasts to the County level, disaggregating the data into three County climatological zones and also builds capacity of farmers to interpret and use weather forecasts, by means of simple mobile phone applications. However, the number of Automated Weather Stations (AWS) is limited (only two AWS operate in the County), the costs of adequate equipment to measure precipitation (especially rain gauges[63]) are high and funding to cover such acquisitions and staff remuneration is limited, diminishing KMD's capacity to deliver on its objectives. Moreover, there is a tendency of implementing organisations collecting environmental/climate data work independently and in isolation from each other, often failing to produce and share data in a coordinated, timely, and meaningful way.

The KFS is a semi-autonomous government parastatal, implementing activities related to climate change, forestry, forest conservation, and ecosystem conservation. In collaboration with the Kenya Forestry Research Institute (KEFRI) in Maseno and other key stakeholders, KFS finances and monitors projects related to ecosystem conservation. KFS engages in tree planting[64] (such as the afforestation project in Nyakach), provides extension services to farmers like providing quality germplasm at subsidised rates and technical advisory. Even though the staff has technical and operational capacity, communities have shown strong resistance to KFS' tree planting initiatives, as community engagement in the planning and implementation of intervention has been minimal, leading to destruction of household property by the free ranging animals (in the absence of fences), or the replacement of indigenous trees with exotic, early-maturing varieties e.g. the fast growing *Eucalyptus grandis*.

The Kenya National Association of Federation of Farmers (KENAFF) is a non-political, non-profit, member-based

60 *The County Government of Kisumu is financing the project and implemented by the line departments, support on the irrigation is however funded by the National Irrigation Board. The projects are ongoing.*

61 *In addition to these, other organizations that carry out climate-related work in Kisumu include: Vi Agroforestry, Care Kenya, Osienala (Friends of Lake Victoria), USAID, Farm Africa, Lake Basin Development Authority (LBDA), the National Environmental Management Authority (NEMA), and the Kenya Wildlife Service (KWS)*

62 *Partners include KMD, KEFRI, ILRI, VI-Agroforestry, CBOs among others.*

63 *One measuring cylinder costs up to KES18,000, while the price of a rain gauge goes up to KES15,000 (the equivalent of roughly US$ 150).*

64 *KFS has a central nursery and sells tree seedlings at a subsidized price, starting with KES12 per tree.*

umbrella organization, which represents the interests of Kenyan farmers (approximately two million families) through focused lobbying, advocacy, and targeted capacity building. In Kisumu, KENAFF is engaged in developing trainings for farmers and community members on soil management, tree planting, and avoiding deforestation, in publishing quarterly magazines on agriculture and forestry-related issues, and in monitoring impact of their trainings through farm visits. However, insufficient funding and human capacity limits the role and impact of KENAFF in the County.

Community Rehabilitation and Environmental Protection (CREP[65]) Programme is an organisation that supports needy small scale farmers, vulnerable individuals and community groups. It supports these groups through promotion of appropriate farming technologies for self-reliance and environmental sustainability. Through cooperatives, farmer groups, self-help groups, and CBOs, farmers are able to reduce production and commercialization risks via access to better financing, acquisition and sharing of farm machinery and other assets, output markets and better negotiated prices. Cooperatives in Kisumu County vary in size and influence and include KICOPE (focused on poultry production), KIPOTRA (focused mainly on chicken processing and selling), Muhoroni Farmers' Cooperative Poultry Society, SIATOK widows and orphans group[66], Kamicha Kabondo self-help group[67], and Friends of Katuk Odeyo (FOKO, among others. There is still need to promote farmers' cooperatives especially in other value chains e.g. sorghum so as to improve the welfare of farmers.

Agro-veterinary companies engage in the distribution and sale of agro-chemicals and other farm inputs and often train farmers on the safe usage of pesticides, fertilizers and other input supplies. For instance, the Magos Agrovet Enterprise distributes drought-tolerant and early-maturing varieties of maize (Drought TEGO and SC Simba 61) and sorghum (Seredo) at subsidised rates. They also engage in the distribution of PICS bags to reduce on post-harvest losses.

By means of demonstration plots, the Agricultural Training Centre (ATC) in Maseno conducts annual field days where farmers and students gain practical knowledge on sustainable land management practices and animal husbandry, feed formulation[68], value addition (yoghurt making, juices, jams, etc.), which can help boost incomes and improve local livelihoods. ATC's educational efforts are complemented by Maseno University, who's recently created Climate Change Department has been seminal in preparing new generations of specialists in climate change and variability-related topics.

The GECCD was initiated by the Governor of Kisumu County as a local governmental structure to promote a clean environment and encourage the reduction of GHG levels in the County. The initiatives run by GECCD include school feeding programme using biogas and the green energy hospital in Lower Kolwa. However, there are challenges that curtail its operations such as accessibility of funds from the treasury.

As discussed in previous sections, a couple of financial institutions provide credit facilities and crop and livestock insurance to farmers, including the Equity Bank, Cooperative Bank, KCB, national banks, and AFC. However, awareness about the availability of such services among farmers is relatively low and capacity to access them is constrained by limited ownership of resources (especially land), low incomes, and no or limited credit history for most smallholder farmers.

Synthesis and Outlook

Climate change impacts have differentiated effects on natural and human systems. Some regions in Kisumu County, such as Miwani and Ombey, the Nyando basin, and the Kano plains, are highly exposed to the adverse effects of floods, while agricultural production in other areas is threatened by prolonged dry spells, higher temperatures and heat stress, including Nyakach, Seme, and Nyando regions. Small-scale farmers depending on rain fed farming for their livelihoods and with limited opportunities to acquire inputs and financial assets are unequipped to fight the negative consequences of climate change and are thus by far the most vulnerable groups. Especially for the Children Headed Households as a result of the loss of their guardian and parents to HIV/AIDS. Hence, silver bullet solutions to the climate-related challenges are counter-productive and unpropitious; measures to manage climate risks need to be tailored to very

65 *It initially started off as a relief and rehabilitation CBO in 1992/3 during the ethnic clashes and eventually registered as an NGO in 1997.*

66 *The group focuses on interpretation of weather, green house farming, and tree nursery.*

67 *The self-help group is mainly formed of women engaged in the cassava value chain and was initiated in response to repeated crop failure due to high soil erosion. With concerted efforts, the group enabled the acquisition of a cassava chipping machine.*

68 *Farmers in Chula Imbo who previously received training from ATC are now selling the formulated feeds in other counties such as Kisii.*

64 *KFS has a central nursery and sells tree seedlings at a subsidized price, starting with KES12 per tree.*

specific contexts and to take into account existing needs and capacities, in order to be viable and to maximize benefits for the people and the environment.

A value chain approach sets the stage for more integrated responses to climate risks; it allows for a better understanding of the vulnerabilities (weaknesses) and capacities (opportunities) of individuals and groups engaged in different economic stages of the production system to tackle climate challenges. Moreover, such an approach offers the opportunity to look beyond the products, to the processes that are essential for comprehensive climate risk management, including value chain governance, information and service provision, value addition, and market access, among others. In Kisumu County, the emphasis on post-production adaptation measures remains narrow. Most resilience-building strategies are found at farm level and are closely tied to the socio-economic and cultural context of each household. Where they already exist, off-farm services are oftentimes limited in coverage or insufficiently coordinated to provide meaningful and timely support to farmers. To close the climate risk gap in the agricultural sector, additional private and public investments are required for technological development and access, innovations in value-added activities, and enabling financial mechanisms and markets for small-holder farmers.

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