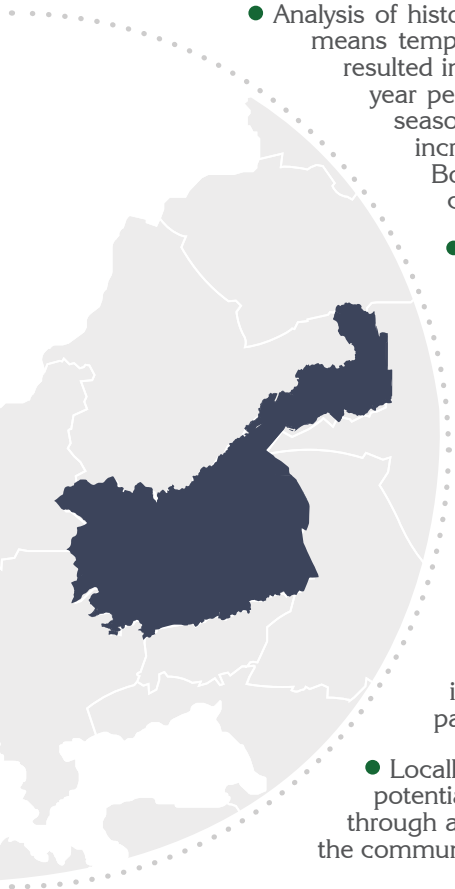
Climate Risk Profile
Kakamega County

Highlights

- Kakamega County has a predominantly crop farming economy with livestock farming taking a small portion of the available arable land. Sixty-one percent of households engaged in crop and livestock production. The total hecterage under food crops and cash crops is 255,483 ha. The proportion of people living below the poverty line in the county is 51.3 percent as compared to the national level of 45.9 percent. The high level of poverty has implications on the county's efforts in development initiatives since no meaningful development can take place with over half of the population still unable to meet their basic needs.



- Analysis of historic climate data for Kakamega in recent decades shows that both first and second season means temperatures have increased by approximately 0.4 and 0.3°C respectively. These changes have resulted in a moderate increase in heat stress days during those periods. Analysis of rainfall over a 35-year period (1981-2015) showed that average rainfall had increased by over 15 percent in the first season and 30 percent in the second season. However, rainfall variability from year to year has also increased, resulting in an increased risk and uncertainty of occurrence of floods and droughts. Both hazards have had increasing impacts on agricultural production and the livelihoods of the county's inhabitants over the years.

- Current and potential adaptation strategies for crop farming include conservation agriculture, soil and water conservation, planting early-maturing and high-yielding crop varieties, agro-forestry and irrigation among others. Improved post-harvest management, and value addition are also practiced as a means of improving incomes and hence resilience to hazards.

- In the livestock sub-sector adaptation strategies include pasture establishment and conservation, disease control and surveillance, use of ethno-veterinary services (indigenous herbs), use of alternative and resilient fodder varieties, formulation of feeds, use of veterinary services, mass vaccination, rearing of drought-tolerant livestock breeds, adoption of feed conservation.

- Despite the on-farm and off-farm efforts to increase resilience to climate change, farmers' adaptive capacity is low and agricultural yields have continued to decrease over the past years. Women and youth are among the most vulnerable groups to climate hazards in the county, yet they also have the lowest adoption rates for adaptation strategies. To fight food insecurity and poverty, efforts should be made to create more off-farm jobs (including in agricultural input supply, processing and marketing) and resilient alternative livelihoods particularly for women and youth.

- Locally identified and indigenous practices and interventions should be examined closely for potential to be integrated into modern resilience building practices, hence encouraging uptake through a bottom-up approach. This may be achieved by supporting investment projects prioritised by the community to improve livelihood.

- Successful implementation of climate adaptation strategies requires strengthening of the institutional and financial capacity of the respective stakeholders. This will enable institutions to provide support and incentives to farmers and thus keep them engaged in sustainable agricultural activities. There is need for accurate and reliable early warning information, and improved extension services, so as to adapt to and cope with the effects of climate change. However, the capacity of these institutions to effectively deliver the services is constrained by limited funds and human resource capacity.

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

List of acronyms

ASDSP	Agricultural Sector Development Support Programme
CBO	Community Based Organization
CIDP	County Integrated Development Plan
ERA	Economic Review of Agriculture
FAW	Fall Army Worm
FBO	Farmers Based Organization
FGD	Focus Group Discussion
FHH	Female Headed Households
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
IPCC	Intergovernmental Panel on Climate Change
KALRO	Kenya Agricultural and Livestock Research Organization
KAVESKenya	Agricultural Value Chain Enterprises
KDB	Kenya Dairy Board
KEFRI	Kenya Forest Research Institute
KENAFF	Kenya National Federation of Farmers
KES	Kenya shillings
KFS	Kenya Forest Service
KMD	Kenya Meteorological Department
KNBS	Kenya National Bureau of Statistics
KWS	Kenya Wildlife Service
MOALF	Ministry of Agriculture, Livestock and Fisheries
MoWI	Ministry of Water and Irrigation
MHH	Male Headed Households
NCCRS	National Climate Change Response Strategy
NEMA	National Environment Management Authority
NGO	Non-Governmental Organization
PSP	Participatory Scenario Planning
ROP	Rural Outreach Programme
SID	Society for International Development
VCC	Value Chain Commodity
YHH	Youth Headed Households

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, and 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 Kakamega County, which is highly vulnerable to climate hazards. The hazards, mostly drought and occasional floods (e.g. in Namulungu and Likuyani), are major contributors to the high poverty and food insecurity in the county. Despite receiving high average annual rainfall, the area is characterised by erratic rainfall and environmental degradation with adverse effects on livelihoods in the county. These effects include declining water availability, drying up of springs and streams[1], reduced rainfall intensity, changes in season onset (and duration), and frequent flash floods. These changes threaten food and water security, increase outbreaks of pests and diseases, and decrease sustainability of livelihoods among farmers. For instance, in 2017, the maize crop in Kakamega County was severely threatened by the Fall Army Worm (*Spodoptera frugiperda*) invasion. The rapidly spreading pest occasioned losses in maize of up to 100 percent[2]. During heavy rains and flooding, humans are exposed to water-borne diseases such as diarrhea, dysentery, cholera, and typhoid. Reduced soil fertility has led to conflicts linked to competition for natural resources[3]. In addition, diseases such as malaria, typhoid, and upper respiratory tract infections have increased; while migration in search of fertile land have increased.

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 climate 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 For example, River Isiukhu which runs through the county and forms part of River Nzoia catchment, has had its land cover reduced due encroachment by communities within and nearby the catchment. Minimal efforts by farmers in conservation activities have led to frequent landslides in Khuvasali village within the catchment (Wekulo, 2017).

2 http://www.the-star.co.ke/news/2017/04/10/armyworm-invasion-in-rift-valley-latest-major-threat-to-grain-basket_c1540238

3 See Wanjala (2016), Wekulo (2017), NAAIAP (2014), Waswa (2012), Diwani (2013), Nambiro (2007), World Agroforestry Center (2006)

Agricultural context

Economic relevance of farming

Kakamega County is located in the former Western Province of Kenya and covers an area of 3,050.3 km^2. The county boarders Vihiga County to the south, Busia and Siaya Counties to the west, Bungoma and Trans Nzoia Counties to the north, Uasin Gishu County to the north-east and Nandi County to the east. It lies between longitudes 34 and 35° East and latitudes 0 and 1° North. Administratively; the county has 12 sub-counties with 60 wards consisting of 398,709 households. It has 12 constituencies, 12 sub-counties, 24 divisions, 72 locations, and 233 sub locations (GoK, 2013).

The economy of Kakamega County is driven mainly by agriculture. According to an ASDSP survey (2014), 22.2, 11.2, and 1.7 percent of households' rear sheep, goats, and pigs respectively. Chicken rearing is predominant with 92 percent of the households keeping them; while only 0.7 percent keep donkeys. Eggs generated KES 17.7 million while 47.6 MT of poultry meat had a value of KES 7.13 million. According to the County Livestock Production Annual Report of 2016, cattle are reared by 53.2 percent of the population and produce about 145.8 million liters of milk and 364,000 kg of beef per year. Aquaculture is the most important fisheries enterprise in the county although it exists at subsistence level with a few commercial fish farm enterprises. Tilapia and catfish form the main fish species cultured. In 2014 there were 6,300 fish farmers in the county with 6,900 fishponds producing 700,000 kg of fish valued at KES140 million annually (GoK, 2014).

On average, annual per capita income was KES 37,429 with salaried employment and farm labour wages constituting the highest proportion of the income. Female-headed households (FHH) earned KES 28,636 while MHH earned KES 42,669. Crop-related on-farm income was earned by 51, 45, and 44 percent of male-, female-, and youth-headed households respectively. Income from livestock activities was earned by 22, 21, and 15 percent of male-, female-, and youth-headed households (YHH) respectively. On-farm income earned a household an average of KES195,333 annually with fisheries activities contributing the largest portion followed by crop activities (GoK, 2014). Seventy six percent of the households did not have enough food for their family needs throughout the year largely due to poverty, small land sizes and lack of market information (FAO, 2016), which further exacerbates the challenges brought about by climate variability. The county is a net importer of agricultural produce.

Female and male adults provided the largest share of family labor in crop production, while the youth provided the least. For livestock production, male adults contributed the highest share of labor while the youth provided the least. Hired labor for crop production was mainly provided by male adults with the youth providing the least share. In livestock production, hired labor was provided largely by the youth. In terms of decision making, females dominated for food crops such as bean, sweet potato, kale, sorghum, *mitoo*, and cowpea vegetables as well as for small livestock such as chickens. Males dominated in making decisions on market-oriented crops such as soybean, maize, and groundnut as well as on cattle. The youth did not have a particular domain in decision-making in crops. This stratified decision making helps safeguard the household's agricultural production capacity ensuring sustained food security and recovery from climate shocks.

People and livelihoods

According to the 2009 Kenya Population and Housing Census, the population of Kakamega County was 1,660,651, consisting of 797,112 males (48 percent) and 863,539 females (52 percent) with a projected average population density of 665 persons per km2 by 2017. In 2012 the population was 1,789,989, and projected to reach 2,028,325 by 2017 at a growth rate of 2.5 percent per annum. This has put great pressure on socio-economic facilities, especially health, education, and land resources and environmental degradation (e.g. depletion of water resources and cultivation of marginal lands).

The county has 220,880 ha of arable land out of the total surface area of 3,050,300 ha. Most of this land is under subsistence crops (43 percent), commercial crops (28 percent) and homesteads (15 percent). Approximately 40 percent of households had title deeds while 51 percent owned land but did not have titles. The predominant settlement pattern is rural in nature. This is reflected by a total rural population of around 72.2 percent as compared to an urban population of 27.8 percent. There is need to encourage optimal use of land through diversification of economic activities and reduce over-reliance on land as the main and only source of livelihood. The Commission on Revenue Allocation states that the proportion of people living below the poverty line (defined as people living below 1 USD per day) in the county is 51.3 percent,

above the national level of 45.9 percent, largely due to high dependency ratio, high population growth rate, sub-division of land, negative cultural practices and influences, low entrepreneurial base, rural urban migration, and overdependence on subsistence and rain-fed agriculture. Other factors contributing to poverty include poor farming methods, overdependence on one cash crop (sugarcane), low-quality livestock breeds and management practices, high population density, poor infrastructure, inaccessibility to quality health, low levels of entrepreneurial skills, inadequate capital to invest in enterprises with high returns, and high HIV and AIDS prevalence (GoK, 2013).

Only 29.5 percent of Kakamega County's households have access to potable water, with 61 percent of residents using improved sources of water, while 84 percent use improved sanitation. The percentage of households with access to piped water is just 5.9 percent, far below the national percentage of 44. Firewood is the most common cooking fuel; being used by 86 percent of MHH and 89 percent of FHH. Only 6 percent of the inhabitants use electricity as their main source of lighting. Approximately 83 percent of the population can read and write, although only 19 percent of the inhabitants have secondary school education while 21 percent have no formal education. Malnutrition is a challenge in the county, with 28 percent of children under 5 years being stunted and 2 percent being wasted (KNBS, 2013).

According to a survey undertaken by the Agricultural Sector Development Support Programme (ASDSP) in 2013, the labor force was estimated at 889,552 in 2012 and projected to reach 1 million people by 2017, representing 49.7 percent of the county population and comprising 471,779 females and 417,773 males. Agriculture accounts for the greatest employment at 756,711 people (although this is not full time employment). Self-employment is important in the county. Sectors that form a substantial number of self-employed persons include the Jua Kali, cottage industries and boda boda. Others are engaged in mining, forestry, brick making, and construction (GoK, 2014).

Agricultural activities

The primary occupation of the inhabitants of the county is crop and livestock production, in which 61 percent of the households are engaged. However, changes in climate coupled with declining soil fertility in the county have an impact on crop production, and hence affect food security especially among small-scale farmers. The main crops grown are sugarcane, maize, bean, cassava, finger millet, and sorghum. Maize, sugarcane are generally grown on large-scale farms while bean, millet, and sorghum are grown on small-scale farms. The main cash crops are maize, tea, and sugarcane. The total acreage under food crops is 114,053.6 ha while the land under cash crops is 141,429.7 ha, the total cropped area being 255,483.30ha.

The county has two main ecological zones: the Upper Medium (UM) and the Lower Medium (LM). The Upper Medium covers the central and northern parts of the county including Ikolomani, Lurambi, Malava, Navakholo, and Shinyalu, which practise intensive maize, tea, beans, and horticultural production mainly on small scale; and Lugari and Likuyani where small-medium scale farming is practised. The LM covers a major portion of the southern part of the county that includes Butere, Khwisero, Mumias East, Mumias West, and Matungu. In this zone, the main economic activity is sugarcane production with some farmers practising maize, sweet potatoes, tea, ground nut, and cassava production.

Kakamega County is endowed with diverse natural resources, which include water and natural forests. The main water sources include the eight main rivers in the county: Rivers Nzoia, Yala, Lusumu, Isiukhu, Sasala, Viratsi, Kipkaren and Sivilie. The county has a natural forest covering Shinyalu and Lurambi; other farm forests have been integrated with agriculture. It has one natural gazetted forest covering 188.7 km2 and one non-gazetted forest that occupy 26.5 km^2. Commercial forests are found in the northern parts of the county. The main forest products include firewood and charcoal as fuel, medicinal plants, honey for commercial and domestic consumption, and timber for construction of houses. These forests are home to indigenous trees, large species of birds, butterflies, monkeys, snakes, baboons, hares, and rabbits. They also attract tourism and provide research sites for a number of institutions (GoK, 2014).

The average farm size is 1.4 ha for small-scale holders while large-scale holders have an average of 4 ha, the small land sizes attributed to high population density. However, land holding tends to be bigger in Likuyani and Lugari sub-counties compared to the other sub-counties. Crop yields are generally low; with maize and bean yields being below 0.9 tons per ha. These issues form part of the multifaceted vulnerability of the county's reliance on rain-fed agricultural production and reduce the capacity of households to respond to climate shocks. However, crop productivity of horticultural crops was high. The livestock department is encouraging dairy farming and upgrading the local

Livelihoods and agriculture in Kakamega

Demographics

ND Of Kenya´s population

1,660,651 inhabitants

ND

48% 52%

Live in rural areas

Access to basic needs

ND of the population lives in **absolute poverty**

Potable water	ND
Electricity for cooking	0.3%
Electricity for lighting	ND
Education (youth literacy rate)	ND

Food security

ND of the population suffers from **food poverty**

ND of household **income spent on food**

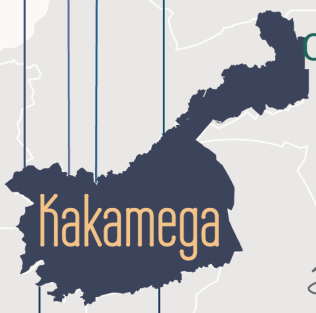
ND People **undernourished**

ND 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

ND ND

ND of the population employed in agriculture production

ND of farmers have title deeds

ND are women

Farming activities

Food crops

Cash crops

Livestock

ND Group ranches

ND Company ranches

ND

ND

Of county´s agricultural land

Farming inputs

Water uses

ND ND ND

Fertilizer types (% of households)

NPK

38% Organic manure

54% Planting fertiliser

51% Top dress fertiliser

Pesticide types (% of households)

4% Field pesticides

15% Storage Pesticides

6% Herbicide

breeds to improve quality and quantity of milk through the one dairy cow per household policy.

With the exception of basal and top dressing fertiliser, technology adoption and input use have relatively low adoption rates. The three major inputs farmers used were planting fertiliser (67.8 percent), organic manure (42.7 percent), and foliar feed (37 percent). Farmers often experience constraints in acquiring seed, planting fertiliser, and foliar feed fertiliser respectively. Youth-headed households used more planting fertiliser in tea growing than male- and female-headed households. In sugarcane production, male-headed households used more fertiliser than female and youth-headed households. About 48 percent of the households[4] had contractual arrangements for marketing their agricultural produce, mostly for sugarcane, while individual farmers funded and marketed horticultural crops- mainly capsicum, tomato, and watermelon on their own. Contract farming allows access to support services (Kweyu, 2013) and also facilitate the adoption of coping and adaptation strategies (Azumah, 2016). Grading and packaging were the most practiced methods of value addition for most of the crops, especially flowers, vegetables, pulses, and roots and tubers. Milling was commonly practiced for grains and to a very small extent, for roots and tubers. Value addition on fiber crops was conducted by 25 percent, chopping by 9 percent, fire wood by 9 percent, and charcoal by 7 percent of the households.

The main input related constraints experienced by farming households included high input prices, timely access to inputs and long distances to input markets. Other constraints were limited access to desired brands and types of inputs, inadequate inputs packaged in inappropriate quantities that are unaffordable by farmers and poor quality of inputs. Use of inputs in livestock production is low with the exception of acaricides, de-wormers and vaccines. Half households accessed agriculture-related services from public providers and were satisfied with the services provided. However, market information, value addition technologies, formal savings, and agricultural credit are generally limited in the county. Access to climate information is generally high, mostly from radio and traditional knowledge, however capacity to respond to climate shocks and early warnings is still low.

Agricultural value chain commodities

Of the broad diversity of crops grown in the county, various value chains have been prioritised 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 (VCCs) were selected for in-depth analysis based on: prioritisation in county frameworks and programmes; economic value (KES/bag or KES/livestock or KES/unit livestock product)[5]; resilience to current weather variability and future climate change[6]; and number of economically active people engaged in the commodity's value chain (including vulnerable groups, women, youth, and the poor[7]). The VCCs selected are; maize, local chicken, cattle (milk), and local vegetables

Maize

Maize is the staple food for the county and is the predominant annual crop; being produced by 81-100 percent of the households. The crop is produced on small to medium scale for both subsistence and commercial purposes in the north-eastern part of the county including Nzoia catchment area. Commercial production at medium scale, is found in the north-eastern part of the county. Small-scale or subsistence production is practiced throughout the county. Maize production is characterised by mixed cropping with women providing the bulk of both skilled and unskilled labor. Agro-dealers sell inputs to farmers at market prices while the county government provides subsidized prices for seed and fertiliser. Some farmers are able to access loans from banks and other financial institutions to support their maize farming. Transporting and marketing is mostly done by the farmers themselves, middlemen and hired transporters. Milling is done both by farmers and local processors.

The crop is grown mostly in the Upper Medium (UM) Ecological Zone covering the central and southern parts of the county. At least 70 percent of maize farmers use improved varieties. In 2014, 70,993 ha were under

4 This is disaggregated as 46 percent of male-headed, 52 percent of female-headed, and 51 percent of youth-headed households.

5 As stated in the 2015 Economic Review of Agriculture (ERA).

6 Resilience is as defined in IPCC (2012); where we consider the general risks posed by climate change in the county. Value chains that are perceived to survive the local conditions under the current production systems holding other things constant (including variations in technology adoption rates among farmers/pastoralists) are considered more resilient.

7 Categorisation of "poor" people was based on workshop participant perceptions and not on any standard index normally used to measure poverty.

maize cultivation and produced 2,026,635 bags of maize. This is the equivalent to 30 bags[8] per hectare (GoK, 2015). About 6.9 per cent of the maize crop is harvested for home consumption while still green. This reduces the final tonnage of maize harvested and exposes many households to hunger (GoK, 2013).

Over 80 percent of the households in the county grew improved (high yielding) varieties of maize[9] using seed from local agro-dealers. Use of planting fertiliser and organic manure is common in growing maize, however sometimes lack knowledge on good agronomic practices such as proper plant spacing and fertiliser application rates. Where pH is below the critical level, there is often need for application of manure, compost or agricultural lime.

Pest and disease control is very important for high grain quality. The main maize pest is helicoverpa (corn earthworm) which affects the tasseling stage, but can be tackled using an integrated pest management system such as a naturally occurring nucleopolyhedovirus (NPV). Maize stem borer (*Buseeola fusca*) and fall armyworm are also major pests which can result in a significant reduction in yields. Diseases such as maize streak virus (MSV), and Maize Lethal Necrosis Disease[10] (MLND), are also common, but can be controlled by ensuring plant health through good agricultural practices as well as through regular scouting for insect vectors and early appearance of the diseases. A survey on the prevalence of MLND in Kenya stated that the severity in the county was 'mild' (Wangai, 2013).

Post-harvest management is assisted through the use of the AgroZ and PICS storage bags which do not require use of chemicals before cereal storage. Some farmers have also invested in modern storage facilities such as household metallic silos. Major constraints affecting the value chain are inadequacy of financial capacity to promote the produce, and exploitation by brokers. In addition weather variability and climate change have affected maize production by changing pest and disease patterns; reduced soil infertility caused by leaching; yield losses due to extended dry spells; and; floods that cause soil erosion (Barasa, 2015).

Chicken (local)

Chicken is one of the ceremonial meals of the Luhya people, hence the importance of local chicken farming in the county. Three distinct production systems exist for poultry and are conventionally referred to as the free range or traditional poultry system; the semi intensive or backyard production system; and the commercial intensive production system. Most local poultry are generally owned and managed by women and children. Free range chicken places few or no additional burdens on owners apart from the provision of household food scraps; the chicken finds their own feed and require little supervision. Improved local chicken are produced in the north-eastern part of the county such as Nzoia catchment area, central and southern parts of the county that include Kakamega town and the environs on small to medium scale levels. The average flock sizes for large-scale production are 100 and above. Commercial production of chicken at medium scale (flock size of 20-100), is found in the north eastern as well as central and southern parts of the county. The small-scale, mixed farming (flock size 1-20) is found throughout the county. In the local poultry value chain, farmers mainly engage in feeding, cleaning, vaccination, deworming, slaughtering, processing, collection, transportation and selling. Simple value addition to chicken includes de-feathering, differentiation of parts and packaging. Value addition to eggs is achieved by boiling, fertilisation, and packaging (GoK, 2014).

In the free-range production system, the chickens are left to gather their own food in the open (free range). The system is broadly divided into two sub systems: mixed farming systems, which include both crop and poultry production; and rearing of improved breeds and crosses. The free-range system forms about 89 percent of the total poultry production in Kakamega County and is largely a low input system. Under this system there is limited breed or age selection, as well as limited feed supplementation. Despite the minimal supplementation, feeding of indigenous chicken is important in order to increase production of meat and eggs, as well as increase resilience to pests, diseases and climate related hazards such as heat waves and droughts. Improved chicken are also utilised. Such improved chicken is dual purpose (egg and meat), laying the first egg around 4.5 months of age, and producing 180-280 eggs in a lifetime. The males are fast growing and can attain a weight of 2kg by 5 months. The high productivity will reduce greenhouse gas (GHG) emissions per unit of product. In 2016, the County Government of Kakamega provided KES22 million to local farmer groups in Khwisero, Mumias West, Lugari, Navakholo, Mumias East, Lurambi, Malava, Shinyalu, Butere, Ikolomani, Matungu and

8 Each bag is approximately 90kgs in weight

9 They include: High Altitude Composite (HAC) (KH600-11D, H600-15A, KH600-16A, KH600-14E, KH600-17A, KH600-18A, KH600-19A, H600-20A, KH600-21A, KH600-22A, H600-23A, KH600-24A, KH600-25A, H600-26A, KH600-27A, H6218, H6213, H6210, 614D, H625, H626, H627, H628, and H629

10 Also referred to as Corn Lethal Necrosis (CLN)

Likuyani sub-county for chicken production. A total of 60,500 improved indigenous poultry, supplied by KALRO, were distributed in the financial years 2015/2016 and 2016/2017.

Breeding management has also become more important, and includes practices such as serial hatching, synchronised hatching, and artificial incubation. Pests and disease management is important in local chicken farming. Important diseases include: Newcastle Disease, pullorum disease, coccidiosis and fowl typhoid. Vaccination technologies include; Thermostable New Castle Disease vaccine – Avivax I and Strategic worm control for local chicken.

Poultry production is one climate change coping strategies, especially through diversification from crop production to poultry farming (Mulinya, 2017). Poultry also play a crucial role in addressing food insecurity and malnutrition in rural households as a source of income generation, asset accumulation and protein.

Cattle (milk)

The dairy sub-sector in Kenya is projected as the most developed in sub-Saharan Africa. At the national level, this sector contributes 3.5 percent of the total GDP. Many of the stakeholders in the dairy sector are subsistence farmers. However, despite its sound performance, Kenya's dairy industry is bedeviled by several challenges including inadequate feeds, prevalence of diseases, unavailability of quality replacement stock, low adoption of technologies, high costs of farm inputs, and low value addition to milk among dairy producers. There is need to encourage dairy farming and upgrade the local breeds to improve quality and quantity of milk through the one dairy cow per household policy and access to modern breeding methods. Modern methods of livestock keeping should be encouraged to enhance production and raise farmer incomes. Zero-grazing is now emphasised as a strategy for commercial farming.

Milk yields in Kakamega average 3.8 liters per cow per day from local cattle during the dry season and 6.1 liters per cow per day from cross-breed cattle. During the wet season, milk yields for male headed households can be as high as 4.2 liters per cow per day from local cattle and 7.2 liters per cow per day from cross-breed cattle. Only 1 percent of MHH sold milk to processors; FHH sold more milk to institutions such as schools and hospitals. About 47 percent of households' boiled milk while 38 percent fermented it as a value addition method, however only 2 percent made higher value products such as yoghurt (GoK, 2014). Between 41 and 60 percent of the county´s population is engaged in the cattle milk value chain, and these are mostly smallholder subsistence farmers. Farmers are involved in activities such as feeding, milking, spraying, transportation, storage, and marketing at small scale. Both private and government veterinary services are available in the county. The Kakamega Dairy Cooperative plays a role in processing and marketing milk. Feeds are sourced largely through farmer groups in Lugari and Likuyani as well as from KALRO Kakamega source feeds. Dairy cattle raised for commercial purposes are found mainly in the north-eastern part of the county, while production at medium scale is practised in the eastern parts of the county.

Other cattle breeds available in the county include: Friesian (average 7,800 kg milk annually); Ayrshire (5,400-7,800 kg milk); Guernsey (average 6,650 kg milk), Jersey (average 6,800 kg milk), Sahiwal (1,500-2,200 kg milk) and their crosses. Several breeding options are available, these include: in-calf heifer and cull cow replacement, artificial insemination (AI), bull services, and assisted reproduction technology (ART). Zero-grazing, stall feeding is used to increase milk productivity, while also providing opportunities for manure management and collection. Other management issues that are important in daily production include feeding strategies such grass selection[11]; use of feed concentrates such as dairy meal, sunflower seed cake, cotton seed cake, bran, and brewer's waste (all of which are sources of energy and protein); use of fodder legumes such as *Leucaena spp*., *Calliandra spp*, and *Sesbania spp*; and use of home-made rations. EM-Fortified milk replacer diets are available at commercial outlets and KALRO centers including molasses-urea mineral blocks and multi-nutrient supplements.

Animal health management is important for the treatment and control of many diseases of dairy cattle. Some of the notable diseases are East Coast Fever (ECF) and Foot and Mouth disease. Immunisation against ECF, routine vaccination and de-worming are necessary while scheduled farm visits by a veterinarian in early lactation and during the breeding period is important. Trypanosomes and ticks are also challenges for production in the county, and can greatly reduce ruminant productivity.

The majority (60%) of the farm systems in the county are small-mixed subsistence (Birnholz C, 2017) that rely on rains for livestock feed and ultimately for good milk production. As such, variability in rain directly affects milk production, with increased milk supply during the rainy season as compared to the dry season (GoK, 2014).

11 Efficient easily digestible feed is important both for productivity as well as for reducing methane emissions.

Local Vegetables

These include Amaranthus (*Terere*), African nightshade (*Managu*), spider plant (*Chisaga*), cowpeas (*kunde*) and Jute mallow (*Mrenda*) (See Annex 1 for more information on the vegetables). Until the introduction of county governments, production of these local vegetables was mainly on a subsistence basis, often by intercropping with other crops. However, some farmers have seen the economic benefits of local vegetables due to availability of markets and have started allocating substantial portions of their land for production. This has also changed the formerly rain-fed local vegetable farming to include planting along riverbanks and/or supplementary watering in some areas during dry seasons. Most farmers still adopt traditional management practices where seeds are broadcast and end up being closely spaced in the field. This provides good ground cover, which reduces the impact of rain water on the soil[12]. During land preparation, the un-harvested parts are ploughed back into the soil, thus adding to the soil organic matter content.

About 81-100 percent of the county´s population is engaged in the local vegetables value chain. Farmers are involved in activities such as buying seeds, land preparation, planting, weeding, harvesting, and marketing. Local vegetables are produced on a semi- commercial and small-scale basis in the south western parts of the county. Commercial semi-small-scale vegetable farming is practiced across the county; mixed farming is practiced in Mumias and Butere sub-Counties. Seed companies, agro-dealers, KALRO, and NGOs such as the Rural Outreach Programme provide seeds and other inputs. Extension agents and NGOs provide small-scale support to on-farm production.

The popularity of local vegetables arises from their high nutritive and medicinal value as well as the large market demand and adaptability to the local environment. Some vegetables like grain Amaranth are currently being incorporated by milling companies into making composite flours due to their nutritive value. However, the fact that most species are open pollinated and their seeds are therefore easily saved by farmers over many seasons has discouraged commercial investment in their seed systems.

Farmers use inorganic fertilisers, organic fertilisers, and manure in local vegetable production. Pest and disease management is important, although farmers have reported fewer incidences of insect pest attack on local vegetables compared with exotic ones. Most of the vegetables have a bitter taste and a strong smell, so they repel some pests. Farmers practising organic conservation farming in parts of western Kenya incorporate leaves and stems of bitter plants in the soil like *Tithonia diversifolia* and *Solanum nigrum* with the aim of keeping off nematodes in vegetable gardens. With this treatment, farmers have reported reduced nematode attack on their exotic vegetables. In commercial farming of indigenous vegetables, pests and diseases such as viral, bacterial and fungal diseases, nematodes, weeds, and insect pests (aphids, moths, thrips, leaf miners boll worms, bugs, mites) may occur. Combinations of attractants, sanitation and traps, bio-pesticides and chemical application have been developed for use by farmers. Post-harvest handling, solar drying and processing technologies to prolong shelf life to maintain quality of local vegetables are available. These include: recipes on utilisation, enhanced utilisation, and continuous availability of vegetable food products and utilisation of by-products such as compost to enhance soil fertility and quality of the environment. However, more research is required on product development and marketing for food and nutrition security.

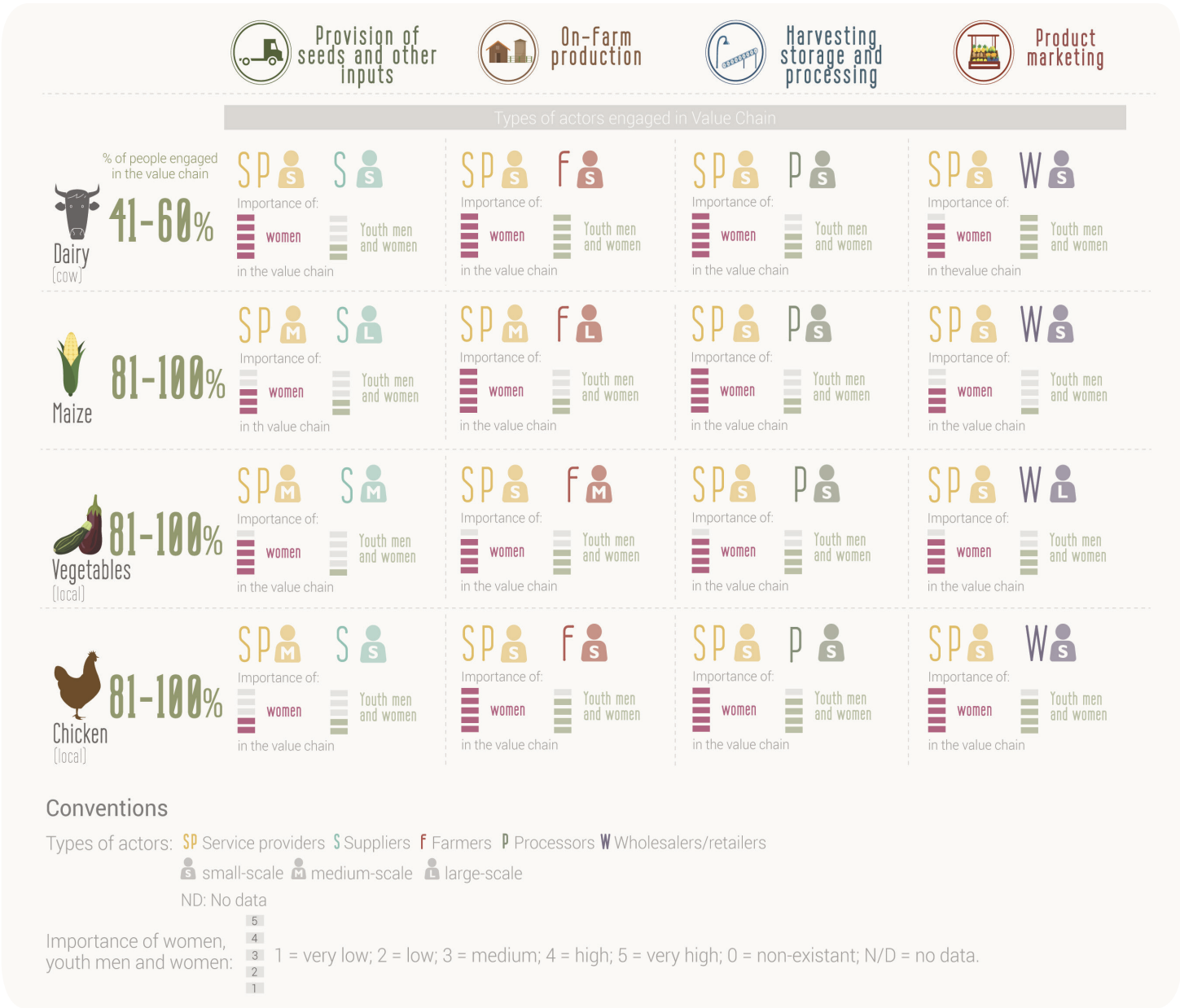
Agricultural sector challenges

Agricultural sector growth and development is crucial to Kenya's overall economic and social development. In particular, agriculture significantly contributes to the national economy; supports food security and nutrition; generates incomes; and provides employment both directly and indirectly for the population. Sustained agricultural growth is therefore critical to uplifting the standards of living of Kakamega people. Kakamega County, however, faces a number of challenges that need to be overcome for this growth to occur. The main challenges to agricultural production in the county include: inability of farmers to afford the optimum use of inputs, technology, agricultural information, financial services, and insurance. Other challenges are: low crop productivity due to declining soil fertility; small, uneconomical sizes of land; lengthy land adjudication processes; poor gender equity in land tenure system; poor farming methods; over-dependence on one cash crop; lack of storage facilities; inadequacy of capital to invest in high- yielding areas; high prevalence of HIV and AIDs; poor road infrastructure, livestock diseases especially tick-borne diseases; and trypanosomiasis.

Farm produce has been reported to go bad due to inadequate storage facilities in the county; post-harvest

12 Local vegetables production is itself considered an adaptation strategy (Stöber 2017) but it still lacks technical information on optimal production and appropriate cropping systems. There has been lack of agronomic packages and access to technical information has been very limited, therefore extension workers have, limited knowledge to advise farmers (Abukutsa-Onyango, 2010).

Agricultural value chain commodities in Kakamega



storage is often handled poorly. Although there are private storage services, very few farmers are able to use these due to inadequate knowledge and inability to transport their produce to these facilities. This may be due to the low income levels of the farmers and to the fact that most of the farm produce is mainly for subsistence in a large number of households.

The key constraints to input use are: high prices, insufficient income to buy inputs, distance to input markets, and lack of access to inputs at the right time. These challenges have increased food insecurity among the local populations. Poor infrastructure increases transportation costs and leads to inflated prices of food and other basic commodities. Poor infrastructure and low market access also hinder effective delivery of perishable livestock products such as milk and meat. The poor state of roads, and lack of modern abattoirs and livestock holding grounds show that government and donors alike give this sector little attention.

It is estimated that 60 per cent of the population in the county do not have title deeds for the land they occupy.

This may be attributed to the lengthy adjudication processes, ignorance, poverty, and the land tenure system. Moreover, cultural beliefs also do not allow women to own family land in their own names. These factors limit investment in adaptation technologies, particularly for women and youth.

Climate change-related risks and vulnerabilities

Climate change and variability: historic and future trends

Kakamega County has a cool, wet climate; mean annual temperatures over most of the county are around 21°C. There is a strong east-west divide in temperatures. The eastern two-thirds of the county have mean annual temperatures ranging from 21 to 23°C; the remaining section in the west has mean annual temperatures below 21°C most of the time. January, February, and March are the hottest months, with other months having relatively similar temperatures except July and August, which have relatively cold spells (GoK, 2013). Annual average rainfall in most parts of the county ranges between 1,250 and 1,750 mm. The average is higher than 1,750 mm in the central and western parts of the county and decreases gradually towards the north-eastern extremity. The rains are evenly distributed all year round with March and July receiving heavy rains while December and February receive light rains.

Floods represent a major risk to crop production and livelihoods in Kakamega, particularly in the lower reaches of the Nzoia River Basin where frequent floods have resulted in loss of lives and properties[13]. Droughts occur and affect large sugar-cane plantations as well as on crop and livestock production. Landslides caused by a combination of intense rainfall, soil erosion, deforestation, and encroachment of agricultural activities onto hillsides have also been experienced[14].

Analysis of historical temperature trends in the county over 25 years (1981 to 2005) shows that both first and second season mean temperatures have increased by approximately 0.4 and 0.3°C respectively. These increases in temperature have resulted in a moderate increase in heat stress days over the periods. Analysis of rainfall trends over a 35-year period (1981-2015) showed that average rainfall had increased by over 15 percent in the first season and 30 percent in the second season. Most of the increase has occurred since 2000. Rainfall variability from year to year has also increased, resulting in an increased risk and uncertainty of the occurrence of both floods and droughts. The impact of both hazards on agricultural production and the livelihoods of the county's inhabitants have been increasing over the years.

Climate projections for the period 2021-2065 based on two representative concentration pathways (RCPs[15]) indicate that in the future, moisture stress, extreme rainfall, and changes in the seasons are expected to occur depending on the emissions pathway. A common projection between the two scenarios is for a moderate increase in mean temperatures during both seasons. In addition, under both scenarios, no significant change is expected in the start of the growing season. However, under the low emissions scenario, the start of both seasons is expected to become more variable and the length of the second season is expected to increase. Under the high emissions scenario, season onset becomes more stable and second season length decreases. Second season rainfall is expected to increase and become more intense under the low emissions scenario, while under the high emissions scenario, rainfall amount and intensity are expected to decrease. The projections under the two GHG emissions scenarios show some differences. However, both indicate the possibility of increased variability and uncertainty in rainfall quantity and intensity, increased temperatures, increased drought stress, and changes in season duration. These changes are likely to contribute to agricultural risk in the county and present some of the main considerations for adaptation responses.

Climate Perceptions by the farmers

Understanding farmers' perception of climate change impacts on natural resources is key in informing policies to make smallholder agriculture in the county more resilient climate change. Frequent crop failures as a result of droughts or high temperatures increase people's susceptibility to food insecurity and poverty. Changes and variations in climate have caused important economic and social consequences. Farmers' knowledge about climate change is key and

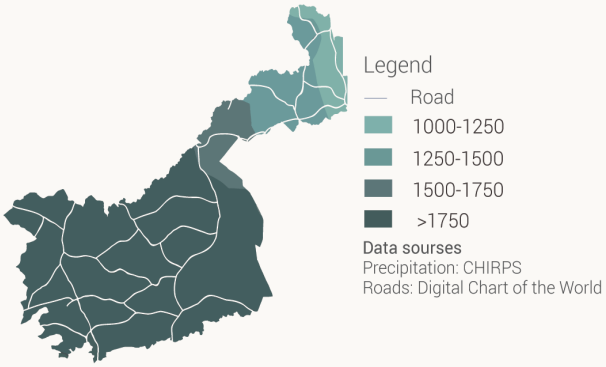
13 http://www.westernkenya.go.ke/index.php/project-areas/kakamega/19-flood-management

14 http://www.humanitarianleadershipacademy.org/the-need-for-disaster-preparedness-in-kakamega-county/

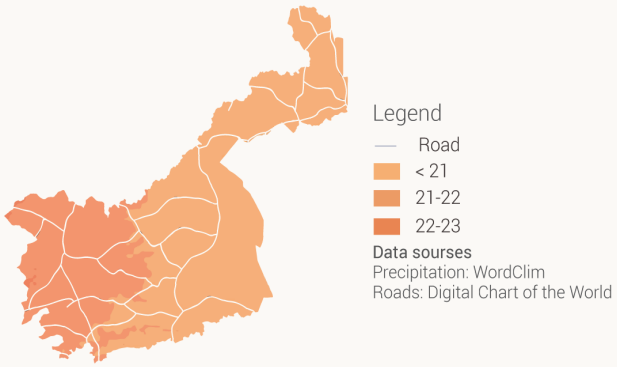
15 The two RCPs, RCP2.6 and RCP8.5, are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6 and +8.5 W/m2, respectively). The pathways are used for climate modelling and research. They describe two possible climate futures, considered possible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

Past and future impacts of climate hazards in Kakamega

Historical annual mean precipitation (mm/year)



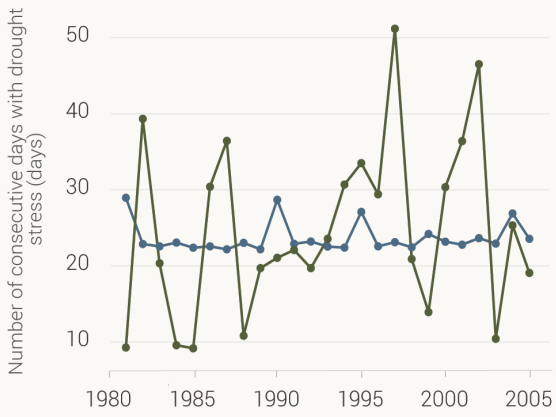
Historical annual mean temperature (°C)



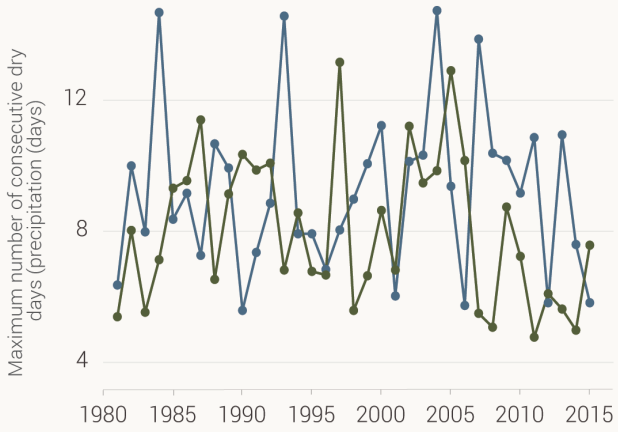
Moisture stress hazards

Drought hazards

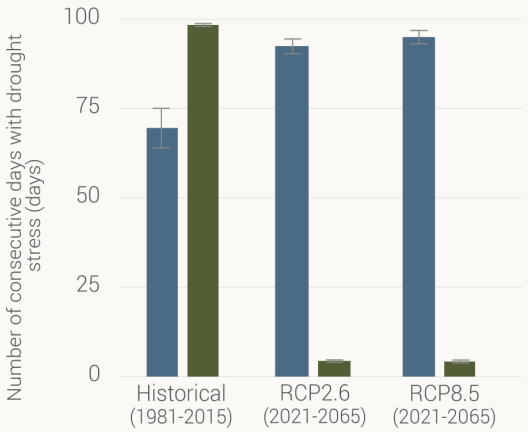
Historical extreme moisture stress events



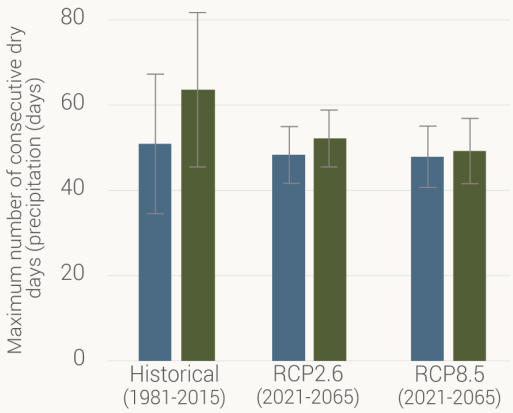
Historical drought stress events



Historical and expected extreme moisture stress events



Historical and expected drought stress events



January - June July - December

largely determines what strategies they adopt in their attempt to reduce adverse effects of climate change.

From the farmers' perspective, there has been a remarkable variation in the climate conditions in Kakamega County over the years. Farmers noted changing seasonality, i.e., delayed onset of rains, for instance from March to April; unreliability and variability of the rains; reduced or increased amounts of rainfall; higher temperatures during the hot season; and much lower temperatures in the cold season. Farmers attested to receiving more erratic rainfall, including unusual early rains followed by weeks of dry periods. Moreover, the intensity of rainfall has increased while delays are being observed in rainfall onset dates.

Moreover, water availability for agricultural production is reported to be under threat from the changing climate given a possible decrease in precipitation. Farmers also indicated the presence of periods of intense rainfall resulting in more frequent mudslides. However, such hazards are said to have been affected not only by climate change but also by conversion of land from forest or fallow to agricultural production.

Overall farmers stated that the weather has become more unpredictable than in the past, mostly as a consequence of human activities and land degradation. High temperatures are reported to have brought about increased incidences of pests and diseases in crops. Outbreaks of diseases and emergence of disease vectors are more common than they were in the past.

These changes are affecting agricultural production and making farmers more vulnerable to climate change. In light of these uncertainties, there is a looming threat to food security, water security, and sustainable livelihoods among farmers. Farmers indicated that access to climate information through extension officers or radio enhances their knowledge on climate change. The government should therefore formulate programmes that can help to disseminate climate change information to farmers, as a key strategy for building resilience to climate hazards.

Climate vulnerabilities across agriculture value chain commodities

Expected future climate change and variation pose serious threats to the value chain commodities prioritised for analysis in this study. Hazards including drought, moisture stress, increased temperatures, intense rainfall, and uncertainty in the start of the season were identified as the most problematic hazards, both currently and in the future. These hazards affect the prioritised value chain commodities differently as seen in the following discussion.

Maize

For effective maize farming, maximum utilisation of available moisture is necessary under any weather conditions. Most maize is grown by small-scale farmers who either consume it at household level or sell it. The major climate hazards affecting the maize value chain are moisture stress and increased temperature. The areas that are mostly affected are the north eastern, western, and southern parts of the county. These hazards impose a number of challenges on the maize value chain. Maize grown during a dry spell with no moisture is normally of poor quality due to poor germination and withering and often results in poor yields. This reduces the final tonnage of maize harvested, thus exposing many households to hunger. On the other hand, the county is characterised by a high population density, poor infrastructure, and limited access to markets; thus raising transaction costs and reducing incentives for both growers and buyers. Other challenges associated with moisture stress and increased temperature include: unavailability of and increased expenditure on production inputs (seeds, fertilisers); poor germination; crop failure; reduced access to extension services; high transportation costs; increased crop infestation by pests; lack of good storage facilities; capacity to add value; reduced market linkage; and hampered marketing. Moreover, heat stress affects land preparation activities since farmers work for few hours per day, when temperatures are still low. The land area cultivated therefore decreases, leading to reduced harvest. Women and youth are generally the group most affected by these consequences. Accessibility of seeds, climate information alerts, and extension services at the right time are essential for ensuring good crop production and food security[16].

Chicken (local)

The major climate hazards affecting local chicken include intense rainfall and drought. The entire county is affected by these hazards. The notable consequences of drought and intense rain include: an increase in the price of poultry feeds[17] and drugs; reduced extension services as the roads are rendered impassable by floods; reduced egg production; reduced shelf life of eggs due to high temperatures; reduced returns from

16 Appropriate mechanization technologies (provided by Bukura Agricultural College and others) can transform smallholder agriculture with spill over benefits including timely operations, reduced cost of production and higher yields more so if used with other productivity enhancing inputs

17 Farmers are encouraged to produce On-farm poultry Feed mixes that can include maize, cotton seed cake, kales, omena and sunflower to increase farmer profits as it is cheaper than commercial feeds but still nutritious.

eggs and birds due to reduced output and marketing as well as transportation constraints; high prices of input due to decreased availability; water shortages; and increased bird mortality due to increased disease prevalence. Women and youth remain highly vulnerable to climate impacts on poultry production, given their scarce resources to buy feeds and lack of access to vaccines.

Cattle (milk)

The main climate hazards affecting milk include dry spells, moisture stress, and increased temperature. The areas affected the most by these hazards are the north-eastern and south-eastern parts of the county. Dry spells , moisture stress, and increased temperatures caused by low and poorly distributed rainfall are the major cause of low cattle milk production in the county. Moisture stress and increased temperature lead to reduced pasture for the animals; hence milk production is reduced as the body condition of the animals deteriorates. Milk is sensitive to high temperatures both at production and value addition (transportation) levels. As a result, milk output is affected, and the produced milk often spoilt before reaching the market. The consequences of moisture stress and increased temperatures range from destruction of fodder crops and pasture, and increases in livestock diseases such as East Coast Fever (ECF) and Foot and Mouth disease, and pests (including ticks).

High ambient temperatures result in milk spoilage as there is no effective refrigeration available to the farmers. Consumers receive less milk when production decreases as a result of prolonged dry spells. Low milk production affects the farmers' food security and livelihoods. Transporters are also affected by the decreased demand for transportation. On-farm feed supply and water decreases, thus leading to reduced production and reproduction, and increased disease outbreaks. There will be a high cost of overall management of the cow such as calf feeding, vaccination, deworming and disease control. There are post-harvest losses because farmers compromise on the quality and quantity of the milk and milk products, reducing their marketability. The ongoing coping strategies for this hazard include training farmers on milk handling, storage, processing, packaging, and transporting. Such trainings are conducted by farmers, extension officers, and the Kenya Dairy Board.

Local vegetables

The major climate hazards affecting local vegetables include drought and delayed start of rain seasons. Areas of the county that are most affected due to moisture stress hazards are the northern and south western parts while central parts of the county experience normal rainfall. Delayed start of rainy season occurs in the south-eastern part of the county.

The consequences of moisture stress and delayed start of rainy seasons cut across the entire VCC from production to marketing stages. Unavailability of and increased expenditure on production inputs (seeds, manure), poor germination, crop failure, reduced access to extension services, and increased crop infestation from the incidence of pests increase the prices of local vegetables affecting consumers across all gender, age, and economic status. Adoption of high-yielding as well as disease- and pest-resistant varieties to increase production is also recommended especially during times of reduced production due to drought. Farmers are encouraged to form farmer groups and associations that will develop appropriate storage and sales facilities for fresh produce. Efficient use of water application technologies through minimum tillage and irrigation is recommended. However, more research is required on product development and marketing for food and nutrition security. Value addition to local vegetables is also considered as an adaptation strategy and can increase their shelf life. The high perishability of the vegetables poses major challenges in their marketing and distribution, particularly in high temperatures. Simple post-harvest handling practices such as bicarbonate wash can help minimize quantity and quality losses and enables availability during the periods when they are in short supply such as during the dry season (Acedo and Weinberger, 2010 in Omulo, 2016). Value addition by applying appropriate production and postharvest techniques such as blanching and freeze drying can extend the shelf life of the processed vegetables.

Adaptation to climate change and variability

Following the adverse impacts of the climate hazards identified along the different value chains, adoption of measures that enhance resilience of the value chains is paramount. Some of the adaptation strategies the farmers in the county are using to cope with climate change and variability are specific to certain value chains whereas others cut across value chains. The measures employed to deal with climate change include provision of environmental education that addresses issues of sustainable utilisation of natural resources, and conservation and protection of catchment areas. For crop farmers, adaptation entails adoption of improved early-maturing crop varieties; use of inputs such as fertilisers, manure, and pesticides; use of irrigation; consulting extension

agents; practising conservation agriculture and good agricultural practices and soil and water conservation; planting early-maturing crops; planting-high-yielding seed varieties; upscaling appropriate modern storage facilities; adopting water-efficient application of irrigation technologies; bulking and cereal banking; trickling early warning information to the grassroots; upscaling power-drawn small-scale machinery; promoting post-harvest management and marketing; planting pest-tolerant crop varieties; harvesting early; practising agro-forestry; and practicing value addition.

For livestock keepers, adaptation entails: conserving fodder; rearing improved breeds; and vaccinating livestock. Additional capacity building of the youth is recommended to promote milk and milk products. Establishment of farmer groups and cooperatives gives the farmer groups a platform to avoid their exploitation. Adoption of modern veterinary technologies (including training of trainers approach) as well as the use of ethno-veterinary services is useful in the control and prevention of diseases. Sensitisation of farmers on adoption of technologies such as hay conservation, silage, urea with molasses, and crop residue management are important strategies for resilience of livestock value chains as well as for natural resources conservation. There is need for the development of plans and policies on resilient breeds and adoption of technologies such as heat/ estrous synchronization, sexed semen, and embryo transfer. Continued lobbying for adherence to the Kenya Dairy Board regulations and their enforcement is on-going and needs to be stepped up. For women main adaptation strategies include production diversification and post-harvest strategies such as food storage facilities. For women-headed households, savings and empowerment groups could also play an important role in raising the adaptive capacity of women while raising their decision making ability. For youth-headed households soil and water conservation technologies, crop diversification, agroforestry / tree planting are important adaptation strategies, although the youth also have an important role to play in off-farm livelihoods diversification including value addition and product marketing. For financially able male-headed households a noteworthy resilience strategy is the leasing of extra land to increase and diversify production in the face of climate hazards (GoK, 2014).

According to the ASDSP (2013), those farmers who noticed climate change planted trees, practiced crop rotation, increased soil and water conservation measures, staggered cropping, undertook value addition, increased irrigation, practiced water harvesting, changed crop type, changed livestock type and breed, practiced feed conservation and diversification, diversified enterprises, established communal seed banks, established food storage facilities, bought insurance cover, leased extra land, and sought employment as adaptation strategies. Overall, the survey results indicate a need for farmers to improve the levels of input use and improve use of methods for sustainable land use, which include reduction in subdivision of farms, agroforestry, and soil and water conservation, in order to increase agricultural productivity and food security in the county. Programmes geared towards improving access to financial and other agriculture-related services will increase productivity and commercialisation, leading to increased household incomes.

The county government should strengthen training in adaptation to climate change, access to agricultural insurance services, and access to socially inclusive financial services. Training on crop species and livestock breed suitability should be emphasized to enhance technology adoption in the county. In building resilience to the shocks of climate change, popular media such as radio and television and membership in groups should be encouraged in disseminating information in the county. Interventions that boost food security should be undertaken. It is also important to boost entrepreneurship, diversify investment in all sectors, increase employment opportunities for the growing number of youth, and invest in high value crops.

On-farm adaptation practices

The main sources of household income were on-farm crop and livestock sales. According to an ASDSP survey, on average of 63.3 percent of households were employed on-farm and derived their livelihood from on-farm activities. Disaggregated by gender, 65 percent were male-headed households, 68 percent were female-headed households, and 57 percent were youth-headed households. Six percent of both male-headed and female-headed households earned from three income sources while 64 and 66 percent respectively of male- and female-headed households earned from a single source. About 40 percent of all households adapted to the perceived climate change. The main source of climate-related information was radio at 36 percent, and traditional indigenous knowledge at 30 percent of all households. Television provided information to about 12, 14, and 13 percent of male-, female-, and youth-headed households respectively. The main on-farm adaptation strategies used in Kakamega County were: planting trees (77.1 percent), changing crop type (62.1 percent), increasing soil and water conservation (50.4 percent), staggering cropping (47.9 percent), and undertaking value addition (31.7 percent).

Soil and water conservation is an important adaptation strategy in the county. It involves preserving soil conditions, maintaining water content with mulching, tree planting and agroforestry, and using manure. High adoption of soil and water conservation measures by youth-headed households may be attributed to the fact that the youth-headed households are more likely to adopt strategies compared to male- and female-headed households, given their increased interest in new technologies. Value addition increases the market value of a product as opposed to selling a raw product. Milk is boiled and fermented while chicken is de-feathered to add value. Value addition for crop production (and mostly in the maize value chains) refers to sorting, grading, transporting, bulking, and processing. These are mostly farmer group initiatives. Farmers are encouraged to form marketing groups or associations to set their own prices and sustainably manage their production levels.

Awareness creation by extension agents on the importance of local vegetables can go a long way in helping farmers to adapt to uncertainties in promoting local vegetables. Value addition was found to be a common adaptation strategy carried out by crop farmers in the county. The biggest challenge to value addition in the livestock and crop sectors is lack of capacity in terms of knowhow, equipment, and financial resources. It helps increase the shelf life of agricultural products while enabling an increase in farmers´ bargaining power especially through activities such as bulking. The challenge of poor access to markets has not been addressed satisfactorily by the on-going adaptation strategies such as selling individually, value addition (given that it is minimal) and premature harvesting. These strategies can be complemented with options such as collective selling, training farmers, and providing the required resources for value addition, as well as engaging farmers in contract farming.

Crop farmers also opt for change in the crop types and varieties they cultivate as a response to increased extreme events. A major impediment to using this strategy is poor access to improved seeds given high prices, but also low productivity of the new crop types and varieties. Using crop residues on the farm after harvesting rather than purchasing manure is recommended. Cooling facilities for milk are necessary to avoid exploitation of the farmer. Adaptation strategies within the livestock sub-sector vary depending on climate hazard. For drought and increased temperatures, the farmers consider water conservation through construction of dams, water pans, drilling boreholes and shallow wells, or rearing more tolerant animals such as indigenous livestock breeds and local poultry that are more resilient to climate-related shocks. Farmers also harvest runoff water and create water pans for irrigation. Western Water Services Company is the main water company in the county. It is supplemented by other water users' associations that are mainly managed by the community members. The concept of Water Action Groups is slowly coming up to complement community efforts. The World Bank in collaboration with the Ministry of Water and Irrigation is in the process of implementing a huge water project in Mumias at a cost of Kes1.4 billion. Tindinyo Water Project also provides water to Shinyalu and Kakamega Town.

Off-farm adaptation practices

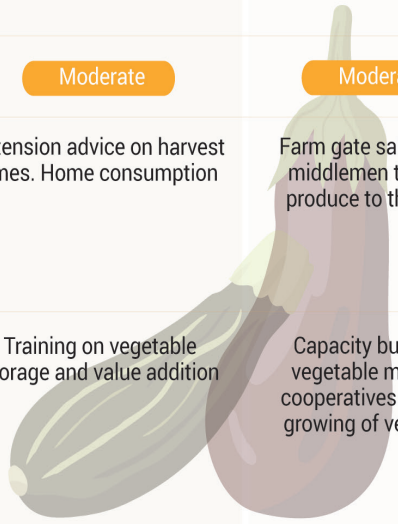
"Off-farm activities" refers to farming activities undertaken outside the household farm setting. The activities could be farming or non-farming in nature. Off-farm activities include salaried employment, businesses, marketing of produce that is not of the household, and remittances. On average, 65 percent of the households had one source of income with 22 percent having two. About 12 percent of the household heads were in formal salaried employment as their main occupation. Besides crop and livestock farming, the youth embarked on formal salaried occupation (15 percent) and self-employment (16 percent). Fewer female adults were involved in self-employment (4 percent) compared to male adults (11 percent), and the youth (16 percent). Sixty-four percent of the individuals were employed on the farm while 36 percent were employed off-farm. On average, 65 percent of the households had one source of income with 22 percent having two. Thirteen percent of the households had more than two sources of income. Disaggregated by gender, 14, 9, and 10 percent of male-, female-, and youth-headed households, respectively had more than one income source. Most MHH had between one and three income sources. Only three percent of all households had more than four income sources (GoK, 2014).

Off-farm services such as provision of early warning systems, insurance schemes, extension and training, storage facilities, and market information are offered to farmers in Kakamega County to increase their climate adaptive capacity. Such services are offered by a variety of stakeholders from local government (such as KMD, veterinary, agriculture, fisheries, and livestock departments) and organisations such as GIZ, Rural Outreach Programme (ROP), Technoserve, and Kenya Agricultural Value Chain Enterprises (KAVES). Extension services are provided by the government and other organisations. It involves field visits, focus group discussions, and workshops on aspects related to the entire value chain. The areas covered include:

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

Vegetables (local)

	Provision of seeds and other inputs	On-Farm production	Harvesting storage and processing	Product marketing
Drought / Moisture stress	Wilting and death of some seedlings. Reduced availability of seeds. Reduction in manure availability	Poor seedling germination rates. Results in formation of hardpans that make land difficult to till. Increased water requirements resulting in increased labour. Increased cases of pests and diseases (aphids, termites)	Reduced quantity and quality of harvest. Reduced shelf life and increased perishability of harvested vegetables. Spoilage during transportation	Increased prices for consumers due to lower supply
Magnitude of impact	Moderate	Major	Moderate	Moderate
Farmers' current strategies to cope with the risks	Obtaining seeds and seedlings from government facilities or research organisations	Early land preparation/ dry planting. Use of minimum tillage practices. Irrigation using buckets. Use of leaves as mulch	Harvesting small quantities at a time. Farm gate sales in small quantities	Use of middlemen to link the producer to the market. Farm gate sales to reduce chances of spoilage before sales. Home consumption of produce
Other potential options to increase farmers' adaptive capacity	Promotion of drought and pest tolerant varieties. Introduction of high yielding varieties	Use of mechanical tilling equipment. Investment in water harvesting and small scale irrigation. Promotion of efficient water use technologies (e.g. drip irrigation). Capacity building on manure management and use	Developing cooperatives for vegetables. Capacity building on value addition	Improvement of access roads to reduce transport times. Establishment of contract marketing
Change in seasons (onset and duration)	Wilting of seedlings while awaiting rains	Poor seedling growth. Delayed recharge of soil moisture. Difficulty in planning farm operations	Poor quality produce. Greater storage and transportation costs. Difficulty in timing harvests. Difficulty in aggregation	Missed marketing opportunities. Irregular supply to markets. Difficulty in meeting market demand. Unstable prices
Magnitude of impact	Moderate	Moderate	Moderate	Moderate
Farmers' current strategies to cope with the risks	Use of mulching and irrigation to protect seedlings. Delayed seed procurement. Delayed manure application	Delayed land preparation. Mulching and irrigation with buckets. Compost production using leaves of various plants. Extension advice on planting dates	Extension advice on harvest times. Home consumption	Farm gate sales. Use of middlemen to link the produce to the market
Other potential options to increase farmers' adaptive capacity	Promotion of early maturing varieties. Local seed bulking. Local seedling production	Promote water harvesting and drip irrigation. Capacity building on integrated pest and disease management. Improvement in access to agro weather advisories for planning of vegetable production operations	Training on vegetable storage and value addition	Capacity building of vegetable marketing cooperatives. Contract growing of vegetables



Maize

	Provision of inputs	On-Farm production	Harvesting storage and processing	Product marketing
Drought / Moisture stress	Lack of availability and affordability of seed and other inputs. Limited finance available. Low demand for agricultural labour	Increased labour required for land preparation due to hard pans. Wilting in the field. Low germination rates. Increased susceptibility to pests and diseases	Low size of cobs. Low crop value and quality. Increased breakage during shelling. Reduced aggregation possibility	Decline in producer prices due to quality. Increase in prices for consumers due to market shortages
Magnitude of impact	Moderate	Major	Minor	Moderate
Farmers' current strategies to cope with the risks	Obtaining seed and other inputs through government subsidy schemes	Replanting. Planting at onset of rains. Reduce land under maize. Use of shared/ rented tillage services and machinery	Premature harvesting to reduce losses in the field. Use of basic hand shellers	Sales to middle men. Home consumption. Reduce prices of produce to encourage sales
Other potential options to increase farmers' adaptive capacity	Use of drought-tolerant and early-maturing varieties. Improve access to weather information to inform farm operations. Enhance drought early warning capacity of meteorological department	Provision of subsidised ploughing machinery for land preparation. Enhance access to crop weather insurance. Diversify production to drought resistant crops. Provision of low cost tractors to ease labour constraints	Provision of metal silos and hermetic bags to reduce post-harvest losses. Capacity building on processing and packaging. Promote bulking	Capacity building of maize marketing associations. Establish cereal banking facility
Increase temperatures	Reduced mobility of input suppliers hence delayed delivery of seed and other inputs. Loss of seed viability	Increased labour costs and reduced labour efficiency due to heat. Reduced mobility of extension agents. Low seed germination rates. Heat stress affects crop water requirements and overall productivity of the crop	Rapid drying of produce resulting in both pre- and post- harvest losses. Increased pest infestations during storage. Poor quality of produce for processing	Less money from sales. Shrinkage and weight loss of the produce (due to moisture loss). Low quality grains affecting commodity prices and ultimate marketability
Magnitude of impact	Moderate	Moderate	Moderate	Moderate
Farmers' current strategies to cope with the risks	Information on climate change from farmer to farmer. Early warning information trickles slowly to farmer. Local sourcing of seed and other inputs	Use of oxen to aid land preparation. Replanting and gapping. Suspension of farm operations during heat waves	Sun drying of produce (taking advantage of heat). Storage in gunny (hessian) bags. Harvesting during cool hours of the day. Minimal value addition	Farm gate sales. Sales to middle men
Other potential options to increase farmers' adaptive capacity	Improve farmer access to weather information to inform farm operations. Use of drought- and heat-tolerant varieties	Promotion of conservation agriculture to protect seeds during heat waves. Establishment and expansion of irrigation schemes. Provision of low cost tractors to ease labour constraints	Increased use of improved silos (e.g. metal silos) and hermetic bags. Heat regulated storage facilities. Capacity building on grading and processing (e.g. milling and use as feed)	Capacity building of maize marketing associations. Sourcing alternate buyers. Establish cereal banking facility. Improve transport so produce can reach the market quicker and with less shrinkage and weight loss

Cattle (milk)

	Provision of seeds and other inputs	On-farm production	Harvesting storage and processing	Product marketing
Drought / Moisture stress	Feed and hay scarcity. Reduced quantity and quality of pasture. Increased veterinary health care requirements. Reduced availability of drinking water	Animal and calf mortality. Emaciation. Low reproduction. Outbreaks of opportunistic pests and diseases. High management cost (feeding, deworming, disease control)	Reduced milk production. Lower availability and quality of milk products. Increased costs for packaging and storage. Dusty conditions lead to milk contamination	Low returns for farmers due to low quality and quantity. Decline in supply to the market. Home consumption (only those with surplus will sell)
Magnitude of impact	Major	Major	Major	Moderate
Farmers' current strategies to cope with the risks	Storing and conserving feed and fodder. Use of crop residues as feed. Purchase of hay and fodder. Selection of drought resistant breeds	Use of indigenous medicines for treatment of opportunistic diseases	Consumption of milk at household level (priority to most needy). Establishment of community milk collection centres with collection schedules	Pooled transportation of milk. Sales at local markets. Group marketing. Home consumption (only those with surplus will sell)
Other potential options to increase farmers' adaptive capacity	More investment in research on drought resistant breeds. Capacity building on feed rationing and different feeding technologies (total mixed ratio, hay, silage and urea with molasses). Promotion of on-farm fodder production and conservation. Intensify artificial insemination	Promote water harvesting for livestock. Improved livestock health management. Investing in weather resistant dairy enclosures. Training of farmers on livestock health management	Construction of milk cold storage facilities. Training on milk value addition for niche markets e.g. milk powder production. Establishment of modern milk collection centres. Engagement of the youth in milk value chains	Improve group marketing though capacity building of cooperatives. Scale up contract milk farming. Improve road networks for easy access to milk markets
Increasing temperatures	Feed and hay scarcity. Reduced quantity and quality of pasture	Low milk production. Low fertility and reproduction rates. Low weight gain. Increased veterinary costs due to heat stress and opportunistic diseases since the animal is already weak. Increased costs for provision of shade	Reduced milk quantity and quality. Increased costs for milk storage, handling and transportation. Increased spoilage of milk during storage. Increased storage and packaging costs to counter outside temperatures	Unreliable supply to the market. Lower returns for farmers due to low quality and quantity of milk produced. Spoilage during transportation to markets
Magnitude of impact	Major	Major	Moderate	Moderate
Farmers' current strategies to cope with the risks	Storing and conserving pastures and fodder. Use of crop residues as feed	Construction of low cost shaded enclosures using grass /thatch). Use of tree shade	Use of shared milk storage facilities. Boiling of milk to increase shelf life. Use of cooler boxes to store milk	Sales in the local market with minimal value addition. Use of motorbikes to transport milk to markets
Other potential options to increase farmers' adaptive capacity	Research on heat tolerant breeds. Training on breed selection. Training on fodder production. Water harvesting and irrigation for fodder production. Training on feed and water conservation	Capacity building and finance for construction of modern shaded enclosure construction. Capacity building on detection of animal heat stress. Water harvesting for livestock	Expand cold storage facilities to all cooperatives. Install processing machinery to reduce milk contamination. Value addition (long life milk and milk powder) equipment and training	Collective marketing through cooperatives (dairy farmer groups). Poling of resources for refrigerated transport. Scale up contract milk farming

Local (chicken)

	Provision of seeds and other inputs	On-Farm production	Harvesting storage and processing	Product marketing
Intense rainfall / Flooding	Poor health of chicks and increased mortality. Spoilage of feed. Spoilage of vaccines	Flood damage to enclosures. Increased incidence of pests and diseases. Low hatch rates	Intense rains result in power outages which affect cold storage and processing facilities	Reduced income for farmers. Reduced access to markets due to impassability of roads
Magnitude of impact	Major	Major	Major	Major
Farmers' current strategies to cope with the risks	Sharing of management and early warning information at fairs, field days and exhibitions. Government repair of flood damaged feeder roads. County government provision of day old chicks. Sourcing of chicks from private incubators. Home feed industries	Use of local materials for construction of raised poultry enclosures. Government vaccination and treatment programmes	Government rural electrification programme. Household slaughter and dressing	Local household consumption. Sales at local poultry sales yards constructed by government. Government repair of flood damaged roads and bridges
Other potential options to increase farmers' adaptive capacity	Support to private incubators to scale up operations. Capacity building of individuals and cooperatives in on-farm feed formulation and storage. Sensitisation of financial institutions on loan risk management for poultry growers	Train farmers on construction of improved (raised and flood resistant) enclosures. Train farmers on disease surveillance and appropriate vaccine regimes	Establish weather resistant collection, slaughter and storage centres at sub-county level. Alternative energy for cold storage and processing (solar, biogas and generators)	Government to improve the road network and pave more roads so they can withstand heavy rains. Contract chicken and egg farming. Establishment of more poultry sales centres
Drought / Moisture stress	High mortality and slow growth rate of chicks. Feed shortages and increase in prices of inputs. Reduction in availability of finance for poultry enterprises	Increased incidence of opportunistic pests and diseases. Increased need and costs for veterinary care. Increased costs on provision of feed and water. High mortality. Low hatch and brooding rates. Low productivity	Reduced quantity and quality of meat and eggs harvested. Reduced shelf life. High spoilage rates of eggs and chickens	Supply not able to meet demand. Low market prices. Death of live birds during transportation
Magnitude of impact	Moderate	Major	Moderate	Moderate
Farmers' current strategies to cope with the risks	Use of internet and farmer-to-farmer information to inform operations. Group input procurement. County government provision of day old chicks Sourcing of chicks from private incubators. On-farm feed production	Destocking (slaughtering and sales of entire stock). Traditional herbs for treatment of poultry. Free ranging so birds can scavenge for food	Government construction of slaughter houses. Construction of cold storage facilities	Local household consumption. Farm gate sales
Other potential options to increase farmers' adaptive capacity	Improved drought early warning systems. Increased use of media to share drought information e.g. radio, television and social media. Harmonize indigenous and modern weather forecasting. Sensitisation of financial institutions on loans for poultry producers. Purchase of milling and feed mixing machinery. Promote drought resistant breeds	Promote poultry insurance schemes. Promotion of water harvesting and water conservation. Train farmers on disease surveillance and appropriate vaccine regimes	Greater investment in modern slaughter houses. Capacity building on meat and egg handling. Invest in modern cleaning, plucking, weighing, grading and labelling equipment. Value addition	Use of specialised poultry transport vehicles. Contract chicken farming. Linking chicken farmers to suppliers

crop planting and growing times, input utilisation and value addition, and amount of product to sell on the market.

Extension training includes fodder conservation, post-harvest handling, proper storage, and marketing. In the livestock sector, farmers have been trained on the importance of disease control and feed storage, which helps increase production. It was reported that the number of farm visits by agricultural officers has been significantly reduced in the past years due to low budgetary allocation. Establishing farmer associations, marketing groups and cooperatives to pool resources will help set their own prices and sustainably manage their production levels and improve on transportation systems. Using household labor rather than hiring external help is often used as strategy to reduce the high cost of labor.

Policies and Programmes

Climate change is a relatively new entrant in the policy agenda in Kenya. The broad policy objective of the agricultural sector in Kenya is to contribute to the overall national development goals of poverty alleviation and equitable income distribution, food security and elimination of malnutrition, and creation of employment and generation of income opportunities, foreign exchange earnings, and import substitution. Contributions to these policy goals will be realised through increased and concerted government support to the farming communities for improved management of the basic, natural and man-made resources necessary for sustainable agricultural development. Policy documents are yet to be mainstreamed at the county level. Currently Kakamega County is using National policies as described below.

In 2010, the Kenya government adopted the Agriculture Sector Development Strategy (ASDS, 2010-2020) replacing the Strategy for Revitalization of Agriculture (2004). ASDS sets out a detailed plan to 'position' the agriculture sector as a key driver for delivering the 10 percent annual economic growth rate envisaged under the economic pillar of Vision 2030. The ASDS Policy proposes the establishment of a national irrigation framework to: (i) reduce the vulnerability of the agricultural sector to drought as it practices mainly rain-fed agriculture; (ii) enable rehabilitation of forests and water catchment areas; and (iii) improve food security, as well as address desertification. ASDS recognizes that reforms in the agricultural sector require drastic actions to take into account the existing and emerging concerns about sustainable agriculture and climate change adaptation in Kenya. ASDS also identifies improvement of livestock breeds, development of pastures and forage, reducing livestock pests and diseases, improvement of water harvesting and management techniques, protection, conservation and sustainable management of forest resources, and rehabilitation of water towers as among the key climate change response strategies for the agriculture sector.

The Agricultural Sector Development Support Programme (ASDSP) was formulated by the government in 2011 in collaboration with development partners and other stakeholders to support implementation of the strategies identified in the Agriculture Sector Development Strategy, ASDS (2010 – 2020) and the Comprehensive African Agricultural Development Programme (CAADP) Kenya Compact. The programme focuses on improved agricultural sector coordination and harmonization; strengthening of the environmental resilience and social inclusion of Value Chains (VC); and promotion of viable and equitable commercialisation of the agricultural sector through Value Chain Development (VCD). The main purpose of ASDSP is to increase equitable income, employment, and food security of male and female target groups as a result of improved production and productivity in the rural smallholder on-farm and off-farm sectors (GoK, 2014). However, in spite of the importance of the sector and the programmes, agriculture has for many years been predominantly small scale, rain-fed and poorly mechanised. In addition, institutional support and infrastructure have been inadequate. The development of agribusiness is critical to the commercialisation of agriculture and realisation of Vision 2030 due to their enormous contribution to employment creation and improvement of the economic status of players along the agricultural value chains.

The National Climate Change Response Strategy (NCCRS), is the framework that guides integration of climate concerns into development priorities, government planning and budgeting (GoK 2010a). It highlights various measures for adaptation to and mitigation of the impacts of climate change on agriculture. These include use of a range of innovative technologies such as irrigation; early-maturing and high-yielding crop varieties as well as drought- and pest-resistant crop varieties and disease-resistant livestock. The NCCRS also advocates diversification of livelihoods; adaptation of agricultural technologies from analogue environments; and enhancing early warning systems with drought monitoring and seasonal forecasts with respect to food security. NCCRS is meant to guide the national and local government in all activities and interventions aimed at addressing issues related to climate change.

The agricultural subsidy and diversification programmes have greatly contributed to food security in Kakamega County. Priority programmes in agriculture include subsidisation programmes on farm inputs and farm mechanisation. Diversification programmes such as dairy, banana, tea, poultry, and fish farming have resulted in

improved food security. Maize production has increased by 40 percent while maize prices have notably stabilised. The One Cow initiative coupled with extensive Artificial Insemination services and regular vaccination services have improved the quality of stock and milk output. Under the Poultry Development Programme, ten groups per ward have been given improved chicks to ensure quality stocks. In the Tea Development Programme, tea tree nurseries have been established and distributed to ensure adequate production to sustain the supply of tea leaves to the tea factory that is under construction besides ensuring regular incomes to farmers. The national government through the Economic Stimulus Programme (ESP) has facilitated setting up of school gardens within the county. These efforts have, among others, contributed to improved farmer incomes and reduced poverty levels from 51 percent in 2013 to 49 percent in 2016 [20].

Several factors undermine the success of climate risk interventions in the county. There is limited availability and effectiveness of early warning information and emergency preparedness that is necessary for averting the impacts of climate change, drought, floods, diseases, and other disasters affecting the agriculture sector. These limit efforts by the government and other service providers to identify and profile key characteristics of the vulnerable groups and, hence, hinder the ability to design appropriate intervention programmes, and the necessary resource mobilisation. A main challenge that hampers enforcement of the above policies and programmes is lack of awareness about the policies, programmes, and norms. The vastness of the county also poses a challenge as it requires a bigger institutional arrangement with wider reach for effective risk management and resilience building, while also affecting the ability to conduct monitoring and evaluation of agricultural adaptation programmes.

Importantly, the county has no local level legislation on climate change which reduces the degree of coordination and collaboration on climate change activities. Attention should be placed on identifying and introducing a climate-compatible strategy or policy or localising existing policy tailored to the agricultural sector in Kakamega. Improving the enabling environment through policy action and governance reform for climate adaptation also requires synergies that are horizontal (across ministries and government agencies) and vertical (between public and private sectors, especially between government and vulnerable stakeholders, including small-scale farmers, women and young groups). Among the systems that need to be put in place are the disaster risk reduction preparedness plan, a contingency plan, and disaster preparedness plans. There is a need for proper management of the County Emergency Fund to ensure an immediate and effective response when disaster strikes in the county. Implementation may also require policy dialogue resulting in institutional reforms and new governance structures that are necessary to achieve resilience in the county.

Governance, institutional resources, and capacity

There are various governmental and non-governmental organizations (NGOs), community-based organizations (CBOs), Farmer based organizations (FBOs), Self Help Groups, Faith Based Organizations, and youth and women groups as well as private organisations in the county that directly or indirectly deal with climate risks. County-level government and research institutions include local offices of the Ministry of Agriculture, Livestock, and Fisheries (MOALF), the Ministry of Water and Irrigation (MoWI), the Ministry of Lands, the Kenya Meteorological Department (KMD), the Kenya Forest Service (KFS), Kenya Forest Research Institute (KEFRI), National Environmental Management Authority (NEMA), the Kenya Wildlife Service (KWS), Kenya Agricultural and Livestock Research Organization (KALRO), the Kenya Dairy Board (KDB), Department of Cooperative and Marketing, the County Economic Planning Department, farmers' organizations, and development partners. The county also hosts large companies such as West Kenya Sugar, Butali Sugar Milling and Mumias Sugar Companies that also influence its growth.

Active NGOs in the county include; GIZ, Rural Outreach Programme (ROP), Technoserve, Grass Root Community Development, Muma Rural Development Forum, and Kenya Agricultural Value Chain Enterprises (KAVES) among others. GIZ supports the county's agricultural sector to increase employment, food security, and drought resilience. A new priority area is technical and vocational education and training for young people, to equip them with appropriate skills to meet the demands of the labour market, especially the private sector. Technoserve supports small-holder producers of indigenous chicken by improving their livelihoods, through among others expanding access to financial services and improving access to poultry markets. Kenya Agricultural Value Chain Enterprises (KAVES) works with smallholder farmers, businesses, and national and county government partners to address constraints up and down the value chain (such as agro-processors, input suppliers, transporters, exporters, retailers, financiers) and develop fully-functioning, competitive value chains. KAVES aims to

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increase the productivity and incomes of smallholder farmers and other actors along the value chain, who are working in the dairy, maize (and other staples), and horticulture sectors, through smallholder enterprise development.

Community-based organisations also exist, and are normally incorporated in the implementation phase of adaptation since they are grassroots organisations that are more able to engage with the farmers within their mandate. For example, The Rural Outreach Programme (ROP) has, as its main objective, to undertake development activities aimed at improving the livelihoods of the rural poor in Kenya. The activities of the organisation have since expanded to include fostering literacy, physical, and mental health. Coordination among these organisations exists at some stages of intervention design and implementation, but could be improved for more effective and sustainable interventions.

The major hindrance to these organisations and the communities they serve is lack of timely and sufficient funding. Insufficient funds contribute to inadequate human capacity, while also limiting sustainability of interventions beyond available project funding. Another area of interest realized was that the status of agribusiness and agricultural entrepreneurs though active in the county, requires support in accessing financial services if they are to compete favorably at international levels. Overall the national level policies and regulations regarding risk reduction and resilience in agriculture are available, however there is need to support local level implementation through finance and capacity building.

Synthesis and Outlook

As moisture stress, extreme rainfall and changes in the seasons are foreseen to occur with greater frequency in Kakamega County, enhanced capacity of farmers to cope with these new conditions is needed. The capacity should involve critical short-term and long-term adaptation measures that target production systems and value chains key for the population's food security and livelihoods, including livestock and crop systems. Significant initiatives to increase resilience in the agricultural sector have been evident in the county. These include on-farm practices that target water and soil conservation and management such as crop rotation, agro-forestry systems, planting early-maturing crops, staggering cropping, undertaking value addition, increasing irrigation, practicing water harvesting, changing crop type, changing livestock type and breed, conserving and diversifying feed, diversifying enterprises, and establishing communal seed banks and food storage facilities as adaptation strategies. In addition, off-farm services and programmes have been provided enable uptake of adaptation options. Such services and programmes include provision of early warning systems and public and private extension services.

Off-farm adaptation support activities also exist including as early warning information, extension services, and microfinance support. Crop and livestock insurance, land leasing, and employment creation, particularly for youth, could also be supported. A long-term vision is needed that addresses the underlying factors affecting farmers' vulnerability and diminishing their capacity to carry out climate adaptation activities. These include education investments in basic public services such as potable water, electricity, and education which could help curb persistent, high poverty among farmers while providing a basis for investment in resilience building initiatives.

Areas that are suitable for growing maize, such as Lugari and Likuyani, ought to be supported with irrigation, transportation, storage, and marketing infrastructure to improve resilience along the entire value chain. Such investments also need to be considered along t entire value chains for other key commodities in the county including milk, chicken, and vegetables among others. Crop diversification (cassava, sweet potatoes, soya beans, and horticulture) as well as value chain diversification and employment creation in the county will also go a long way to improving resilience. Policy support at local level as well as financial (subsidies and ready markets) and non-financial incentives (e.g. agricultural inputs) will play a key role in supporting adaptation activities in the county.

Climate hazards are expected to affect not just the production stages of agriculture but also, input supply, storage, processing and marketing; hence investments in resilience building have to be strategically made at all stages of the value chain, while also taking into consideration the specific needs and constraints of men, women and youth. There is also a need to encourage adoption of improved breeds and modern stall fed dairy systems that can help improve productivity, while also contributing to reduced methane emissions and environmental degradation. Training on overall good agricultural practices including animal health management will also be key to building the resilience of agriculture in the county to climate and other hazards.

An enabling institutional and policy environment and a broader governance mechanism are also critical for addressing climate vulnerabilities of farmers. The formulation and implementation of county-level climate change action plans that are grounded in assessment of local needs and resources could represent an important step towards the operationalisation of the country's climate change strategy. The provision of appropriate financial and human resources and equipment to implement these strategies and policies at local level will also be crucial, particularly in a vast county like Kakamega. This includes the strengthening of the Kenya Meteorological Department, particularly on community engagement and tailoring the message to the needs of smallholder farmers in the county. In addition, the improvement of coordination among agricultural climate change adaptation and value chain actors is needed, along with enhancement of the monitoring and evaluation system for their work within the county.

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