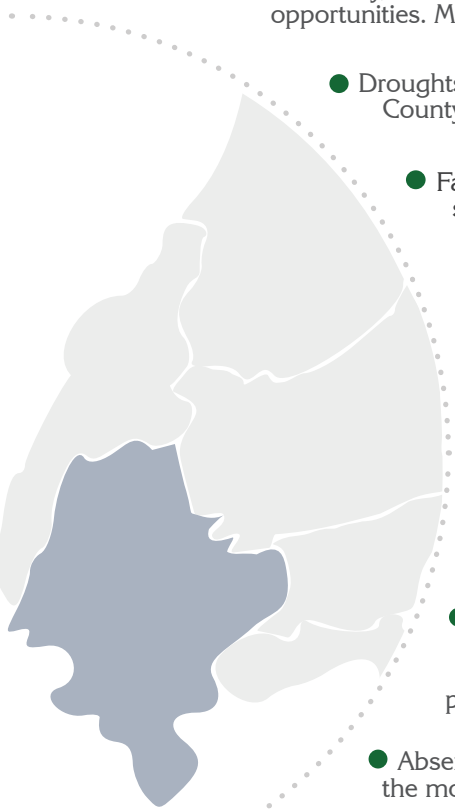
# Climate Risk Profile
# Siaya County

## Highlights



- Siaya County is characterised by high poverty levels (47.56%) and food insecurity. Agriculture is the main source of livelihood in the County, contributing about 60% of the household income and providing almost 61% of all employment opportunities. Maize, beans, sorghum, and local poultry are the key value chain commodities in the County.
- Droughts and intense rainfall already constrain agricultural productivity and food security in Siaya County; climate projections indicate increasing events of drought and intense rains.
- Farmers in Siaya County employ a host of on-farm strategies to cope with climate risks and shocks including: planting of drought-resistant crop varieties, diversification, conservation agriculture, value addition strategies, animal feed conservation, and farmer groups to ease access to credit, farm inputs and market information. The main constraints include high costs of inputs, and limited access to credit and extension services.
- Low adoption of agricultural technologies, low use of inputs, high cost of credit, and poor quality soils are some of the salient factors that exacerbate the impact of climate change and variability.
- Off-farm services that assist farmers to mitigate climate change and variability include early warning information on drought risks and food security assessments. Farmers in flood-prone areas along river banks and basins receive early warning information on amounts of rainfall and water levels in catchment areas.
- The private sector, with the support of non-governmental organizations, is playing a key role in helping farmers adapt to climate change. For instance, the East African Breweries Limited (EABL) is promoting growth of sorghum, which is drought tolerant. It contracts farmers and provides financial support, extension services, and a stable market.
- Absence of County-specific legislation, low technical, financial, and human resource capacity are the most common institutional hindrances to climate risk management.
- There is need to fast track the drafting and operationalization of policies on climate risk management to be mainstreamed in County plans.

KaPP
Kenya Agricultural Productivity Programme
Republic of Kenya
WORLD BANK GROUP

# List of acronyms

| | |
|---|---|
| **AEZ** | Agro-ecological zones |
| **ASDSP** | Agricultural Sector Development Support Programme |
| **DID** | Department of Irrigation and Drainage |
| **EAAPP** | East African Agricultural Productivity Project |
| **EABL** | East African Breweries Limited |
| **ECF** | East Coast Fever |
| **EMCA** | Environmental Management and Coordination Act |
| **ERA** | Economic Review of Agriculture |
| **EWS** | Early Warning System |
| **FAO** | Food and Agriculture Organization |
| **GoK** | Government of Kenya |
| **KACCAL** | Kenya Adaptation to Climate Change in Arid and Semi-Arid Lands |
| **KALRO** | Kenya Agricultural and Livestock Research Organization |
| **KAPP** | Kenya Agricultural Productivity Programme |
| **KES** | Kenya Shillings |
| **KFS** | Kenya Forestry Service |
| **KMD** | Kenya Meteorological Department |
| **KNBS** | Kenya National Bureau of Statistics |
| **KPHC** | Kenya Population and Housing Census |
| **KRC** | Kenya Red Cross |
| **LM** | Lower Midlands |
| **LSD** | Lumpy Skin Disease |
| **MoALF** | Ministry of Agriculture, Livestock and Fisheries |
| **NDMA** | National Drought Management Authority |
| **NEMA** | National Environmental Management Authority |
| **NGO** | Non-governmental Organization |
| **NMK** | Njaa Marufuku Kenya |
| **PSDA** | Private Sector Development in Agriculture |
| **PSP** | Participatory Scenario Planning |
| **THVC** | Traditional High Value Crops |
| **VCC** | Value Chain Commodity |
| **WB** | World Bank |
| **WFP** | World Food Programme |
| **WKCDD&FMD** | Western Kenya Community Driven Development and Flood Mitigation Programme |
| **WRMA** | Water Resources Management Authority |
| **WRUA** | Water Resource Users Association |
| **WV** | World Vision |

# Foreword

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

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

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

This document presents the Climate Risk Profile for Siaya County, where climate variability has been accompanied by a significant increase in risks, as often reported in national news. In 2013, severe flooding caused the Nyando and Nzoia rivers to break their banks, destroying fertile farmland and leaving more than 200 residents homeless[1]. Amongst the hardest hit sub-counties were Alego Usonga and West Ugenya. These two are the agricultural hubs that provide neighbouring sub-counties with vegetables and sugarcane among other goods, so the floods had County-wide food security implications[2]. Just three years later, in 2016, extreme flooding again led river banks to overflow, inundating cropland and washing away livestock and poultry of some 169 households[3]. Efforts to address flooding and subsequent droughts have led the government to introduce drought-resistant maize varieties with appropriate sorghum breeds as alternative crops. International organizations have contributed to the efforts by providing inputs and introducing to farmers new technologies such as soil and water conservation management[4]. The disastrous nature of extreme weather makes identification of impending climate risks urgent. Introduction of practices that increase farmers' resilience in the face of imminent threats to their health, safety, and livelihoods is equally urgent.

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

1 As reported by the online newspaper The Star (The Star, 2013a).

2 As reported by the online newspaper The Star (The Star, 2013b).

3 As reported by the online newspaper Citizen Digital (Citizen Digital, 2016)

4 As reported by the online newspaper The Star (The Star, 2015).

# Agricultural context

## Economic relevance of farming

Siaya County is situated in Western Kenya. It is one of the six counties that form the Nyanza region. It neighbours Vihiga and Kakamega Counties to the North-East, Kisumu County to the South-East, Busia County to the North and Homa Bay County across the Winam Gulf. It has a land surface area of 253,000 ha and a water surface area of 100,500 ha. The water surface forms part of Lake Victoria.

The agriculture sector contributes 60% of the total household income and provides approximately 61% of all employment opportunities in the County (GoK, 2013). According to the Agricultural Sector Development Support Programme (ASDSP), at least 37.3% of households are engaged in crop and/or livestock farming (GoK, 2014). The main food crops include: maize, beans, sorghum, millet, cowpeas, sweet potatoes and groundnuts while the main cash crops include; cotton, rice, sugarcane, and groundnuts. Both family and hired labour, comprising mainly women and youth, is used at all nodes of each value chain.

Subsistence farming is practised on 51.1 % of the total County arable land where food crops cover 150,300 ha; cash crops take up 1.2 % or 2500 ha of the land. The mean annual total household income is KES 124,286. The mean annual on-farm income earned by households in Siaya County is KES 31,961 with crop sources contributing an average of KES 20,352 while livestock sources contribute an average of KES 19,000. Among the food crops, sorghum and beans are sold by 87.6 and 35.5% of the households respectively (GoK, 2014).

## People and livelihoods

According to the Kenya Population and Housing Census (KPHC) of 2009, the total human population of Siaya County was 841,682, 52.6% of whom were women. With a growth rate of 1.7% per annum, the population is projected to increase to 964,390 by 2017. The average population density is 12 persons per square kilometers (km2). Siaya County's population is predominantly rural, with 93 % of the population residing in rural areas.

Poverty rates are estimated at 47.56% of the population of the County, compared to 43.37% at the national level. Incidences of poverty are higher in rural than in urban areas, standing at 58% and 38% respectively (GoK, 2013). High levels of poverty in the County can be attributed to low agricultural productivity, dwindling fish resource and few income sources. Access to water in the County is very low; only 5.9% of the population have access to piped water. The County depends on expensive sources of energy for lighting. Most of the population (93.9%) uses kerosine and only 4.3% uses electricity. Firewood and charcoal are used by 84.5 and 13.4% of households respectively for cooking. The high demand for wood fuel puts pressure on the tree resources and thus reduces the forest cover in the County. The literacy rate in the County is 80%. Around 71% and 98% of the community live within 0 - 4.9 km of the nearest public primary and secondary school respectively (GoK, 2013). This could explain the high literacy levels observed.

Food insecurity is high in the County, and is characterised by scarcity of food, fewer meals per day for most households, and limited diversity in family diets. Previous reports classified 80.7% of the households as food insecure (GoK, 2014). Siaya County has a stunting rate of 24.7% and a wasting rate of 0.2% (KNBS, 2014). This suggests that food production in the County does not match food demand by the increasing population. Unreliable and poorly distributed rains, low use of inputs, poor crop husbandry, and a negative attitude by a high proportion of the population towards agriculture explain this food deficit.

Most households in Siaya depend on crops, livestock, and fishing for livelihoods. The main food crops include maize, sorghum, millet, bean, cowpea, cassava, sweet potato, finger millet. The main vegetables are tomato, onion, and kale while the main cash crops include cotton, sugarcane, and ground nut. Some of the emerging crops in the County include: soybean, palm oil, chilli, and grain amaranth. Fruits grown in the County are mango, pawpaw, banana and watermelon. The main livestock types are Zebu cattle, dairy cows, dairy goats, poultry, local goats, sheep, pigs, rabbits and bees[5]. Livestock are largely indigenous with the Zebu cattle constituting 90% of the cattle population. Almost all households (99%) own local chicken. The main activity in fisheries is capture in Lake Victoria

5 Reports by the Livestock Production Office in the County indicate that there were 5,698 dairy cattle, 492,591 beef cattle, 143,752 sheep (wool), 4,652 dairy goats, 260,252 meat goats, 13,453 pigs, 12,324 rabbits, 63,688 broiler chickens, 40,394 layers, 804,161 indigenous chickens, 24,262 other types of chickens, and 7,719 donkeys, among other animals.

and Lake Kanyaboli as well as fishing in dams and fish ponds (GoK, 2015).

## Agricultural activities

Siaya County has a land area of 253,000 ha and a water area of 100,500 ha. The arable land is 200,000 ha, representing about 80% of the total County area. The area under food crops is 150,300 ha while that under cash crops is only 2,500 ha (75.2% and 1.25% of the total agricultural land respectively). The rest of the land is either unutilized or underutilized.

The main agro-ecological zones (AEZ) in Siaya County fall under lower midland zones (LM) ranging from LM1 to LM5 with pockets of upper midland zones which have a high agricultural potential (Jaetzold et al., 2010).

The Lower Midlands (LM1) have an annual average precipitation of 1500-1900 mm, annual mean temperatures of 21.8-20.9°C and an altitude of 1300-1500 m. Areas under LM2 have an annual average precipitation of 1400 -1600 mm and annual mean temperatures of 22.3-21.5°C while under LM3 have an annual average precipitation of 1020-1390 mm and annual mean temperatures of 22.7-22.0°C. These are sub-humid and humid zones with reliable precipitation. Areas under LM4 have an annual average precipitation of 890-1020 mm and annual mean temperatures of 22.7-22.3°C. Areas under LM5 are found in the lower parts of the County around the shores of Lake Victoria. Both LM4 and LM5 are semi-humid, semi-dry lower midland zones. The predominant soil type is ferralsols. Its fertility ranges from moderate to low with most soils being unable to produce without the use of organic, inorganic, or in most cases both types of fertilisers. The soils are therefore degraded, have poor moisture retention and are of poor quality with nutrients severely depleted hence of low productivity. Black cotton soils, loams and red volcanic soils are also found in some areas of the County.

The average farm size for small-scale farmers ranges from 1.02 to 3 ha and varies with sub-County. The average farm size for large-scale farms is approximately 7 ha. About 35% of the farmers own title deeds in the County (GoK, 2013). According to the Household Baseline Survey, the most common land tenure is ownership without a formal title (59.8%) followed by ownership with formal titles (30.7%). This implies that long-term investments cannot be made on the lands. This is because of limited collateral for securing loans for development and other economic enterprises.

Farmers in Siaya County use inputs such as labour and seed/planting material in crop production, and acaricides, de-wormers and vaccines in livestock production. Roughly 44% and 53% of the labour used in crop and livestock production respectively is hired. This increases production costs and reduces productivity. The use of local seeds is prevalent in the County. This practice, coupled with low usage of fertiliser, has contributed to low productivity. Farmers cite high prices of inputs and the distance to input markets coupled by high poverty as major reasons for low use of inputs. Only 1% of the households use irrigation (GoK, 2013). The area under irrigation in Siaya County is 680 ha while the potential irrigable area is 7150 ha. Thus only 10% of the potential irrigable land is actually irrigated. The expansive Yala Swamp has a potential for large-scale irrigation using River Yala as manifested by the Dominion Farms, which have 450 ha of irrigated rice, and are also involved in sugarcane farming.

## Agricultural value chain commodities

There is a broad diversity of agricultural production systems in Siaya County. Various value chains have been prioritized for development interventions by different government organizations and programmes, such as the ASDSP, the Kenya Agricultural and Livestock Research Organization (KALRO) and University of Nairobi survey, and the Kenya Agricultural Productivity Programme (KAPP). For the development of this County Climate Risk Profile, four major value chain commodities (VCCs) were selected for in-depth analysis, based on their contribution to food security, productivity characteristics and importance to the economy. These VCCs have been selected from a list compiled from the above-mentioned documents using the following prioritization indicators: harvested area (hectares), production (90-kg bags), variation in production (in the past five years), value of production (US$/bag), dietary energy consumption (Kcal/capita/day), protein content (g of protein/100 g of product), iron content (mg of iron/100 g of product), zinc content (mg of zinc/100 g of product), and Vitamin A content (IU Vitamin A/100 g of product). The VCCs selected for this study are maize, bean, sorghum, and local poultry.

### Maize

Maize is a key staple food for Siaya County's population. It is grown in all the agro-ecological zones in the first and second seasons of the year. Over 80% of the County's population, the majority of whom are small-scale farmers, grow the crop. As such it is contributing significantly towards the food security of the households and the harvested area. The acreage

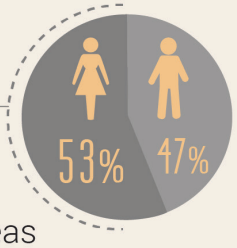
# Livelihoods and agriculture in Siaya

## Demographics

2.3% Of Kenya´s population

885,762 inhabitants

94% Live in rural areas




## Access to basic needs

48% of the population lives in **absolute poverty**

| | |
|---|---|
| Potable water | 8% |
| Electricity for cooking | 0.2% |
| Electricity for lighting | 4% |
| Education (youth literacy rate) | 80% |

## Food security

34% of the population suffers from **food poverty**

ND of household **income spent on food**

ND People **undernourished**

23% Children **stunted**

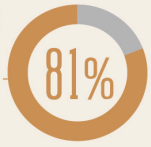
0.2% Children **wasted**

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 205,900ha




ND% of the population employed in agriculture production

35% of farmers have title deeds

ND% are women

## Farming activities

### Food crops


### Cash crops


Of county´s agricultural land

### Livestock

Cattle (dairy and beef heads) 5,698 and 492,591

Goat (dairy and meat, heads) 4,652 and 260,252

Chicken (dairy and beef heads) 804,161

## Farming inputs

### Water uses

ND ND ND

### Fertiliser types (% of households)


40% Organic manure

41% Planting fertiliser

15% Top dress fertiliser

### Pesticide types (% of households)

1% Field pesticides

4% Storage Pesticides

2% Herbicide

under maize in 2015 was 85,000 ha. Maize production was 1,530,000 bags of maize worth KES 3.67 billion.

The average maize yield per unit area is low due to inadequate use of recommended certified seed and fertiliser, the striga weed menace and the erratic and unreliable rainfall. This has led to deficits that are covered by imports either from the neighbouring counties or countries. The maize produced is predominantly for household consumption and thus household food security and is rarely sold. Some of the key activities in maize production are land preparation, planting, weeding, and harvesting. Since maize is mainly produced for household consumption, most of these activities are practised by women and the youth with little or no involvement by men.

## Bean

Beans are regarded as a key staple food for Siaya County and is grown by over 80% of the population. Over 90% of the bean crop is intercropped with maize; however, productivity is low due to use of poor quality, mainly recycled seed, low usage of fertiliser and poor pest and disease control. According to the County directorate of agriculture, Siaya County produced about 306,000 bags of beans valued at KES 1.836 billion. The beans are grown in all the agro-ecological zones in the County, mainly for household consumption. However, due to the high prices of beans relative to those of maize, farmers tend to sell some of the beans produced to get money for their needs despite the low yields. They can be sold either at farm gate or at nearby local markets. Some of the key activities in beans include: land preparation, planting, harvesting, drying, and threshing. Women perform most of the activities associated with growth of beans.

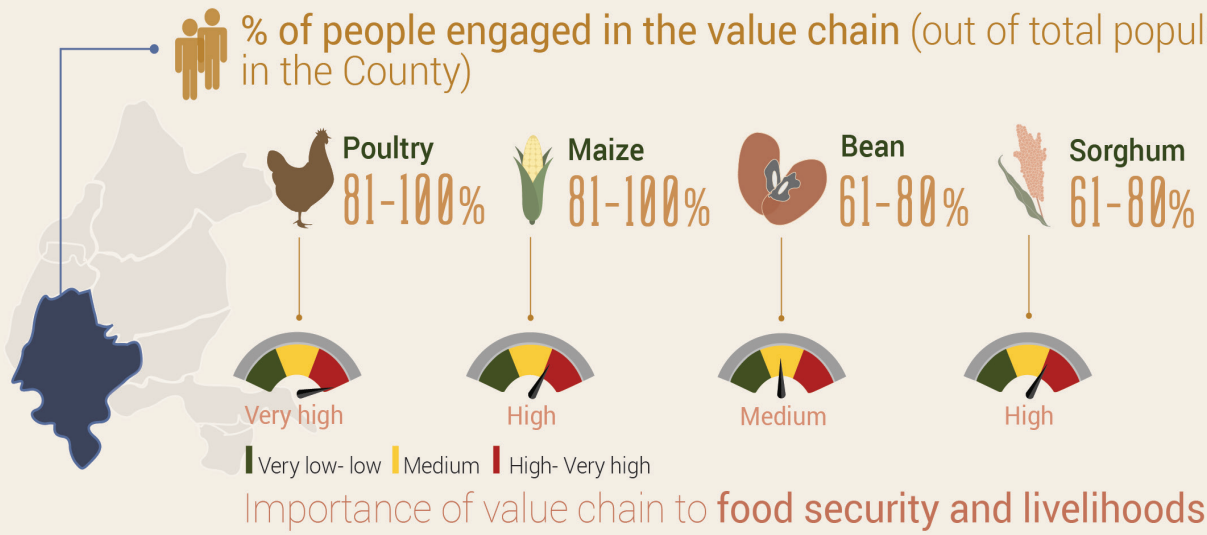
## Sorghum

In Siaya County, sorghum ranks second in importance after maize as a food and cash crop. It is a preferred crop for up to 80% of the farmers in the County due its ability to tolerate drought. It can produce reasonable yields with the limited rain and fertility prevalent in rainfed farming in the County. Sorghum matures within three months and the seeds can be recycled, offering farmers steady income. According to the crop statistics provided by the County Directorate of Agriculture, farmers produced 192,000 bags of sorghum worth KES 460 million in the past year. Previously farmers grew sorghum for subsistence but with the increasing use of sorghum as an alternative to barley in beer making, East African Breweries Limited (EABL) is now contracting the farmers for commercial production. Some of the key activities in sorghum production are: land preparation, planting, weeding, winnowing and harvesting. Women are the majority in farming and marketing sorghum.

## Local Poultry

Poultry keeping is common among all households in Siaya and is practised semi-intensively. The majority of poultry farmers are women, as men are more engaged in cattle farming. In 2014, there were about 804,161 indigenous poultry in the County and production of eggs stood at 630,495 egg trays (30 eggs per tray) (GoK, 2015).

## Agricultural value chain commodities in Siaya



Indigenous poultry score highly in terms of food security due to availability of eggs and meat which provide high sources of protein, thus playing a key role in household nutrition. They are also a quick source of income because the eggs can be sold in the local shops while the poultry can be traded in the nearby local markets. Local poultry take approximately 6 to 8 months before they are ready for the market. Poultry and eggs that are not sold in the local markets are sold in Kisumu, about 70 km away.

## Agricultural sector challenges

Agricultural activities have been affected by a number of challenges that have reduced productivity. Underfunding and understaffing has led to reduced effectiveness of extension services due to a high farmer to staff ratio. This has led to poor crop husbandry and low absorption of modern technology, notwithstanding the many innovations at the farmers' disposal.

Over-reliance on rain-fed agriculture, use of local seeds instead of improved seeds, and high costs of inputs and animal feeds have exacerbated the situation for the resource-poor farmers.

Continuous cultivation of the fields and environmental degradation depleted soil nutrients, which have not been replenished by manure and fertiliser application. Brick making, quarries, bare areas, and sand harvesting all contribute to environmental degradation.

Inadequacy of soil and water conservation structures has led to on-farm surface runoff thus reducing infiltration and washing away nutrients. Some areas in the County are prone to waterlogging during rainy seasons, thus leading to reduced yields. High prevalence of crop and livestock diseases and the rampant use of traditional livestock breeds have contributed to reduced agricultural productivity. Due to poor security, livestock - mainly cattle and chicken are stolen, thus further impoverishing farmers.
Increased incidences of diseases such as malaria, water-borne diseases, HIV and AIDS have led to loss of productive labour force.

# Climate change-related risks and vulnerabilities

## Climate change and variability: historic and future trends

Siaya County is fairly hot (21-25 °C) and moist (1000-1750 mm precipitation annually). There is a strong precipitation gradient with the northern areas receiving more than 1750 mm, and the southern areas closer to Lake Victoria receiving 1000-1250 mm of precipitation. Both temperature and rainfall are high during most of the year, although the first wet season (January-June) receives higher and more consistent precipitation than the second season (July-December). Intense precipitation and heat stress are both hazards that contribute to agricultural risk in the County throughout the year, whereas dry spells are common in the Second wet season.

Analysis of climatic data for Siaya County shows that both dry spells and extreme precipitation are hazards in the County. Dry spells are on average longer during the second wet season, with consistently close to 60 consecutive days of moisture stress. Consistent moisture stress occurs for fewer than 30 days during the first season. Extreme precipitation and flood risks[6] are moderate to low in both seasons, with most years receiving 10-25 mm of precipitation on the wettest day[7].

Climate has already been observed to change slightly in the County. Since 1981, the first wet season, has experienced a ~0.5°C increase in mean temperature and reduction in crop cycle, but little to no change in precipitation on average. However, there has been an increase in drought risk due to hotter temperatures. The Second wet season experienced no change in temperature but had an increase in precipitation of approximately 15-25%. This has resulted in increased risk of flooding but fewer dry years and associated drought risk.

Projections for 2021-2065 show that prolonged moisture stress will occur in the first season of the year, whereas precipitation will change little in either season. Within 30 years (by the early 2040's) temperature is projected to increase by 0.4°C, with the First wet season projected to experience even greater changes. And by this time, precipitation is projected to increase by 0.5% in the first wet season and 3% in the second. Consecutive days of moisture stress are projected to almost double in the first wet season from approximately 25 days to around 40-45. In contrast,

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

7 Note that this is 20 mm on average over the entire County, so specific parts of the County will have experienced greater than this (possibly much greater), whereas other parts will have experienced less.

moisture stress in the second wet season is projected to decrease from over 60 consecutive days to 45-50. These projections of future climate change under the two climate scenarios - RCP 2.6 and RCP 8.5[8] - show some small differences, but generally the same future projections, suggesting that climate change impacts will be fairly similar during this time frame regardless of the amount of greenhouse gases that occur.

## Climate vulnerabilities across agriculture value chain commodities

Expected future climate change and variability pose serious threats to value chain commodities prioritized for analysis in this study. Hazards affecting the agricultural sector include floods, drought, landslides, increased temperatures, and increased incidences of pests and diseases. Droughts and intense rainfall were identified as the most problematic climate hazards both currently and in the future. These hazards affect the prioritized value chain commodities differently as seen in the following discussion.

### Maize

Maize production is mainly affected by drought and intense rainfall. Drought is a normal occurrence in Siaya County especially in the lower zones found near the lake such as Rarieda and Bondo sub-counties (LM3, LM4 and LM5 zones). It affects the key stages of the value chain, especially input supply and on-farm activities. Drought causes hardening of soils, hindering land preparation and thus delaying planting. It results in poor germination for maize because of limited soil moisture. The upshot is reduced yields or total crop failure.

Intense rainfall causes water logging, since the soils are prone to flooding (black cotton type). This affects land preparation, planting, fertiliser application, weeding, and harvesting. Some of the inputs - mainly fertiliser, are normally washed away during flooding. On-farm operations like weeding, fertiliser application and harvesting become very difficult and sometimes impossible. Flooding also affects post-harvest processes as it leads to rotting and even marketing of outputs as the roads become impassable. Women are mostly affected since maize is regarded as a food security crop for the households and also since women provide most of the family labour on maize farms.

### Local poultry

Local poultry is practised by almost every household in the count. The enterprise is affected by drought and intense rainfall; agro-ecological zones LM4 and LM5 are the most affected as drought and intense rains are more prevalent in these zones. These areas are characterized by low altitudes with black-cotton and sandy loam soils. Drought and intense rains reduce quality and availability of poultry feeds. They increase the frequency of disease outbreaks; poultry are very vulnerable to diseases such as Newcastle. The high temperatures make the vaccines unstable. Chicken farmers, especially women and youth, remain highly vulnerable to climate impacts on poultry production, given their limited capacity to buy feeds and vaccines.

### Bean

Beans are grown in all the agro-ecological zones in Siaya County as an intercrop with maize. Bean production is affected by drought and heat stress hazards that predominantly occur in LM4 and LM5. Drought and heat stress interfere with the cropping cycle by reducing germination, flowering, and productivity. Drought makes land preparation difficult due to formation of hardpans, reduction of seed viability, and increases in the cost of labour. Women are the ones who normally grow beans; they make at least 45% of the decisions in growing crops like maize, beans, groundnuts, and sorghum (GoK, 2013). They are therefore the most vulnerable when the hazards occur. The key activities affected most by the hazards are input supply and on-farm production.

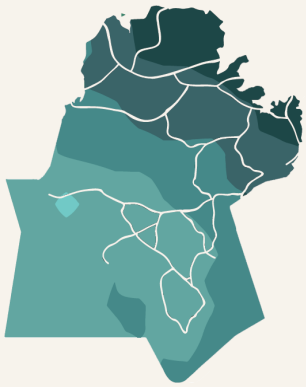
### Sorghum

Sorghum is a drought-tolerant crop which has steadily been grown, replacing maize in some places since it requires less water. However, it is affected by intense rainfall and heat stress or a dry spell. These hazards occur in AEZs LM3, LM4 and LM5, where sorghum is grown and which apparently experience intense rains. At higher altitudes, sorghum gives poor yields and suffers increased pest attack. The intense rains cause waterlogging, making farm operations such as ploughing, planting and weeding very difficult and time consuming. In addition, the intense rains cause delayed harvesting, rotting due to poor drying, difficulties in transportation and hence poor quality which compromises the prices of the commodity.

8 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.

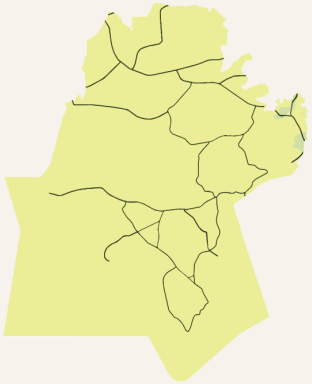
# Past and future impacts of climate hazards in Siaya

## Historical annual mean precipitation (mm/year)




Data sourses
Precipitation: CHIRPS (1981-2015)
Roads: Digital Chart of the World

## Historical annual mean temperature (°C)

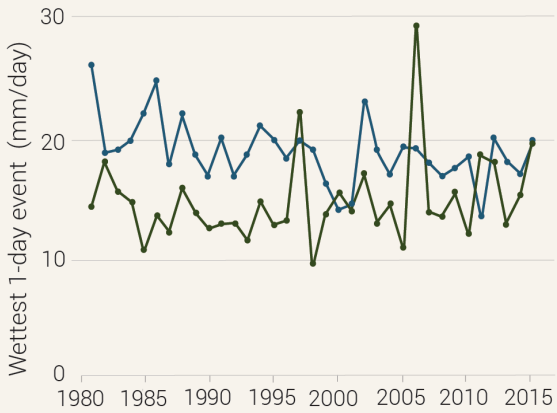



Data sourses
Precipitation: WordClim (1970-2000)
Roads: Digital Chart of the World

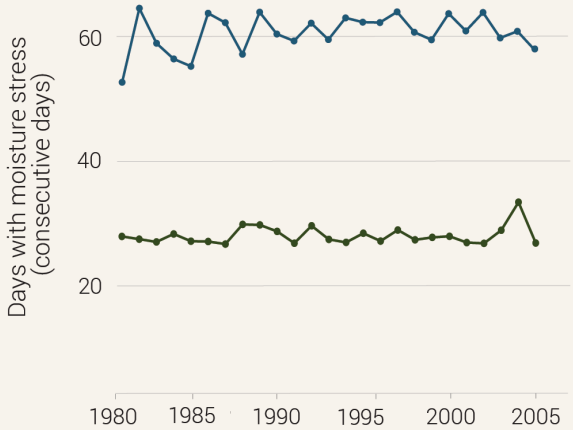
## Flood hazards

## Drought hazards

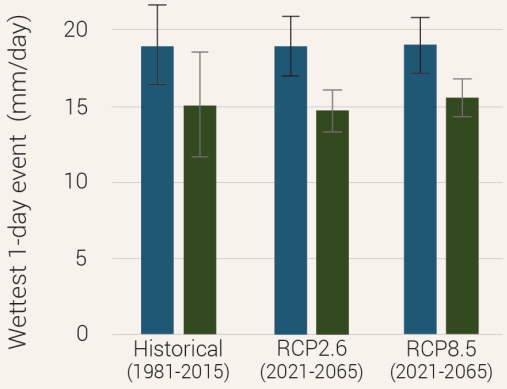
### Historical extreme flood events



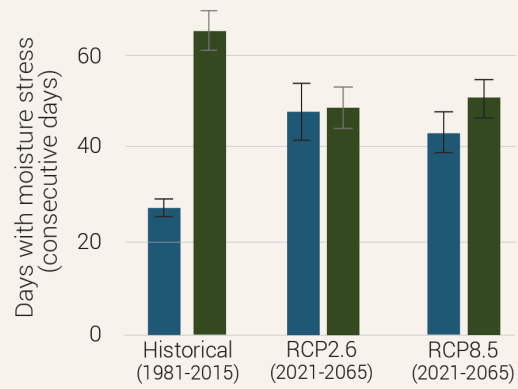

### Historical drought stress events




### Historical and expected extreme flood events




### Historical and expected drought stress events




January - June  July - December

# Adaptation to climate change and variability

The County's agro-ecological and climatic characteristics increase its exposure and vulnerability to climate hazards, impacting farming and livelihoods. Some areas are categorized as semi-humid and semi-dry lowland zones (LM4 and LM5) that receive reduced rainfall. The rains have poor temporal and spatial distribution. Owing to their proximity to the lake, these areas experience high temperatures due to their low altitudes, leading to heat stress.

Moreover, soil types also increase this vulnerability. The main soils are ferralsols, with moderate to low fertility. Most of the areas in the County have soils with poor moisture retention. Black cotton soils in other areas are very hard when dry and very sticky when wet, providing perfect conditions for flooding during heavy rains and this creating inadequate conditions for farming (and especially high yields).

To minimize vulnerability and impacts of climate risks, farmers in Siaya County have adopted various strategies to adapt their production systems and livelihoods to a changing climate. Several institutions have offered services to enable on-farm adoption of these strategies, by building technical and financial capacity among farmers.

## On-farm adaptation practices

Farmers' vulnerability to climate variability is linked to their dependence on rainfall. In Siaya County, farmers are planting drought-tolerant crops (sorghum, cassava, sweet potato) to adapt to climate change and variability. About 36.4% of the households in Siaya have adopted crops tolerant to dry conditions, which require less water to grow. (39% and 37% of female- and male-headed households respectively) (GoK, 2014).

In addition to these, farmers are also planting short-maturity crops such as DK8031, DH04, DUMA 41, and cowpea. They are increasingly using certified seeds to improve germination and hence yields. The main challenge faced by farmers in adopting this strategy is the prohibitively high cost of seeds and long distances to input markets where they can get inputs.

Two rivers traverse Siaya County - Rivers Yala and Nzoia. Farmers living along these two rivers are practising small-scale irrigation to harness the water resources and reduce dependence on rain-fed agriculture. About 8.8 and 8.5% of male- and female-headed households respectively have adopted irrigation (GoK, 2014), mainly for growing kales and tomatoes. Drip irrigation is also being practised in some parts of the County such as Bondo sub-County. Currently only 680 ha out of a potential 7150 ha of land has been irrigated. Dominion Farms Limited has reclaimed 450 ha of the Yala swamp for rice production. Irrigation requires equipment and the cost can be prohibitive, leading to farmers using methods that are not water-efficient or incurring extra costs. This leads to increased cost of production. In addition, inadequacy of water for irrigation is a constraint especially for areas far from rivers and the lake shoreline.

About 44% of the households plant trees on their farms as a climate change adaptation strategy (GoK, 2014). Farmers plant multipurpose agroforestry trees which act as fodder and improve the soils due to their nitrogen-fixing abilities. Some of the tree species being promoted are fodder trees such as sesbania, leucaena, calliandra and other trees species like Grevillea robusta that can be grown together with crops. Farmers also grow fruit trees such as mangoes, oranges, and pawpaws which produce shade for other crops and fruits that earn extra income to farmers. Energy-saving jikos are used to reduce the amounts of wood fuel used, avoiding thus deforestation. However, lack of seeds and seedlings for planting, high costs for establishment and maintenance of nurseries (especially in terms of labour and water resource requirements)[9]- are major barriers for scale out of the practice throughout Siaya County.

Since some parts of Siaya County are affected by floods and intense rainfall, measures have been taken to conserve soil and water. This includes structures such as dykes, retardation basins, gabions, terraces, and water pans. These help to capture water and control its speed during intense rainfall or floods. Strips of Vetiver grass are planted on some of these structures to help retain the soil while allowing the water to pass. Some of the challenges in adopting this strategy include lack of the technical know-how required to establish the structures on the farms. This challenge is due to the limited extension services provided to the farmers by the relevant departments. Some of the structures are costly and labour-intensive so they cannot be adopted by the resource-poor farmers.

Some farmers are also adopting conservation agriculture, including intercropping (maize and bean) and the use of cover crops such as Dolicos, ground nuts, and sweet potatoes. It is assumed that since beans take a shorter duration in the field than maize, at least the farmers will not lose both crops.

9 Most tree seedlings have to be raised in nurseries before being planted.

Farmers have also reported the use of organic manure on the farms to improve soil fertility, help in water retention and maintain soil moisture by reducing evaporation. Increased use of manure helps to contain some weeds specifically one called "Kayongo" or striga weed, that is prevalent on maize farms in the County. The weed has caused economic losses running into billions of KES.

Some livestock farmers opt for fodder conservation technologies, such as hay and silage for future use. To the moment. about 8% of households (predominantly women-headed) in Siaya County have adopted some form of feed conservation. Poultry farmers grow termites and maggots to provide feed for their birds, given their resistance to climate hazards. Scarcity of information on feed formulation and conservation is the main challenge facing farmers. The scarcity is attributed to limited extension services provided to farmers by relevant authorities due to budget and human resource limitations.

Due to increased incidences of diseases, vaccinations are administered to animals in areas that are prone to diseases such as Lumpy Skin Disease (LSD), foot and mouth and East Coast Fever (ECF). Poultry farmers also use traditional herbs such as aloe, pepper, and sisal extract to treat poultry diseases.

Farmers in low midlands of the County do not keep improved cattle breeds since they believe that indigenous cattle are better suited to climatic variability than improved breeds. Moreover, they prefer to graze their animals rather than confine them in intensive zero-grazing units. Similarly, poultry farmers also practise some form of semi-intensive management where the birds roam about to look for feed and to avoid high temperatures that occur during confinement.

Farmers, mostly women, have formed small groups that provide pooled rotational labour to overcome high labour costs. Some of the groups practise table banking, offering the members readily available credit devoid of the rigours of the formal banking sector. This increases the resilience of members against climate-related shocks. Some of the farmers have also formed cooperatives to link them to markets and to ensure that the farmers earn better prices. The groups and cooperatives provide access to extension services, enabling farmers prepare for risks.

Farmers in Siaya County are venturing into other sources of income to mitigate the effects of climate variability. Some of these activities include: sand harvesting, brick making, gold mining, and charcoal burning. Even though the alternative sources of income cushion the farmers against the vagaries of climate variability in the short term, these activities are not sustainable and lead to environmental degradation. This leaves the farmers worse off due to their long-term negative effects on the environment. Other farmers also seek off-farm employment as a strategy of adapting to climate change. In Siaya County, 12% of female heads of households sought employment as opposed to 6 and 6.3% of male and youth heads of households respectively. However, off-farm employment opportunities are scarce, which exacerbates the already high unemployment rate in the County.

## Off-farm adaptation practices

Off-farm services are offered by public and/or private bodies to enable farmers to cope with climate risks and adapt to new climatic conditions. A number of such services will be discussed in this section, including: Early Warning Systems (EWS), off-farm employment, or off-farm income-generating activities.

Early-warning services (weather forecasts) are provided by the ASDSP together with the Kenyan Meteorological Department (KMD). Assessments of the long and the short seasons are provided to prepare other stakeholders, mainly extension workers, to advise on the measures to take in their respective areas of operation in relation to their activities. This helps farmers to undertake activities like early land preparation and planting, dry planting (for crops like maize and beans) and timely planting. All these activities are geared towards maximizing the use of the rains when they eventually fall. Other EWS are provided by the Water Resources Management Authority (WRMA) for the Nzoia and Yala Rivers, which are prone to flooding. WRMA has a monitoring system along the rivers from the catchment areas (upstream) which monitors the rainfall and the water levels and triggers an alarm to downstream people when the water rises to dangerous levels.

Together with the community, WRMA also developed a community-based water flood hazard map that indicates where floods occur based on experience, the depths of the rivers, and where people seek refuge. The authority has come up with a flood management plan that starts from the water catchment to the river basin. The challenge facing the EWS is the lack of automatic weather stations measuring a wide array of parameters, which can help provide accurate and reliable weather forecasts. Currently, the County has very few stations that are not automated, that have only rain gauges and therefore are limited in providing accurate forecasts since only one parameter is measured.

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

## Poultry

| | Provision of seeds and other inputs  | On-Farm production  | Harvesting storage and processing  | Product marketing  |
|---|---|---|---|---|
| Intense rainfall | Increased feed losses (moulds/rotting); limited access and high feed/drugs costs due to transport challenges; low access to breeding chicks; high labour requirements and costs | Increased feeding rates; high energy requirements (heating); increased diseases prevalence (coccidiosis) and flock mortality; high costs of veterinary services | Reduced slaughter hygiene (increased chances for contamination); limited transport (farm to storage); increased perishability (eggs/carcase); increased labour requirements (dressing); divert to household consumption | Low farmer sale prices (farm gate); reduced marketing activities and linkages (limited market access); market scarcity (poultry products); increased market prices (brokers/traders); high perishability of products |
| Magnitude of impact | Major-Minor | Severe-Major | Minor | Severe-Minor |
| Farmers' current strategies to cope with the risks | Proper storage of poultry feeds/supplements (moisture free); use of improved/traditional poultry breeds; use of chicken cross-breeds; use of drugs/traditional herbs for pests and diseases control | Proper drainage around poultry houses; vaccination/traditional herbs (control of disease outbreaks); warming of poultry houses (firewood/lantern); proper husbandry (cleaning houses, drinkers, feeders) | Timed slaughtering (few at a time); defeathering chicken for storage/sale; manual collection, grading and sorting of eggs; household consumption (low quality eggs) | Sale to middlemen at farm gate prices; promotion of chicken marketing (open field days/agricultural shows); hording chicken for seasonal festivities (high prices) |
| Other potential options to increase farmers' adaptive capacity | Establish feed drying units (ward level); farmer sensitization on veterinary services; establish county supported policies on feed formulation; improved road infrastructure (facilitate feed access) | Community construction of dykes, check dams and canals; promote use of solar/electric heating systems; use of footbath at poultry houses; limiting access to houses (reduces contamination); enterprise diversification (dairying) | Introduce community based slaughter and storage facilities; promote small scale cooling and refrigeration facilities (cooler boxes); poultry enterprise diversification (Duck/ goose/rabbit/dairy farming) | Strengthening of extension services; sale of chicken parts (as opposed to whole chicken); strengthening of farmer cooperatives (marketing/market activities); explore value addition strategies for chicken products |
| Droughts | Low quality and high cost of feeds; feed scarcity; increased vaccine instability; limited access to poultry drugs; increased water demand; low labour requirements; labour scarcity | Reduced flock vitality (reduced: feeding, brooding, breeding, egg-laying); malnutrition (low feeding rate); low growth rates; increased pest and disease incidence; high labour costs | Low hygiene of slaughter facilities; low carcase weights; increased labour (in chicken dressing); increased incidence and rapid perishability (high temperatures); increased energy requirements (cold storage and refrigeration) | Market scarcity (of poultry products); reduced farmer prices (farm gate); loss of market and marketing opportunities (undefined markets); shift in market focus; increased market prices (brokers/traders) |
| Magnitude of impact | Severe-Moderate | Major-Moderate | Minor | Moderate-Minor |
| Farmers' current strategies to cope with the risks | Improved poultry house construction (orientation and design); purchase of feeds and vitamins to cooperatives/groups; temperature control; use of traditional herbs (Aloe vera, pepper extracts) | Flock planning; IPM using local herbs/concoctions; establish feeding and watering regimes; culling of sick birds; free range management (supplement feeding); ventilation of housing facilities; poultry water sanitization | Use of cold storage facilities (meat) and moisture free boxes (eggs); timed slaughtering; manual egg collection, cleaning, grading and tray packaging; defeathering of poultry carcases; egg incubation (for breeding chicks) | Use of individual and group sale of eggs and meat (farm gate and local markets); value addition at sale points (frying/boiling/stews); sale of breeding chicks; sale to chicken brokers/merchants; hording of poultry products (improve market prices) |
| Other potential options to increase farmers' adaptive capacity | Research on economical housing designs; improved poultry breeding programmes; promote growing of local grains (as feeds); county support to establish feed miller (per subcounty); introduction of thermostable vaccines | Improved brooder technology (facilities); capacity building and access to modern disease and pest facilities; research into improved poultry housing (using local resources e.g. hyacinth reeds) | Dry slaughtering; sterilizing of slaughter facilities (slaughtering points); use of cooler boxes and refrigeration facilities (carrying meat); community; post harvest value addition (innovate new chicken products) | Improve supply contracts through continuous production; communitary marketing and promotion of chicken products (to external markets); standardize poultry products prices (County policies) |

# Maize

| | Provision of seeds and other inputs | On-Farm production | Harvesting storage and processing | Product marketing |
|---|---|---|---|---|
| Droughts | Low quality of planting seeds; labour scarcity; high labour costs | Delayed planting; challenges in ploughing/ planting; poor crop germination and establishment; low agronomic efficiency; increased pests infestation | Low quality (low density) and poor harvest quantities; increased post harvest damage (pests/rodents); reduced post harvest value addition and commercial processing opportunities | Reduced farmer prices (low quality); increased trader prices (scarcity); reduced market activities/linkages; divert produce to local markets and household consumption; reduced household income |
| Magnitude of impact | Major-Moderate | Severe-Major | Severe | Severe-Moderate |
| Farmers' current strategies to cope with the risks | Use of drought tolerant, early maturing and certified seeds; reduced use of inorganic and organic fertilisers | Timely planting; use of family/local labour at planting and weeding; use of draught animals (planting); dry planting; conservation agriculture; agroforestry; enterprise diversification (kales/tomatoes /legume/root crops) | Manual harvesting, winnowing, grading and packaging; use of traditional storage preservatives (ash); use of metallic silos and hematic bags; sun drying (of harvested maize stovers); diversified use of storage facilities | Farmer individual sale (farm gate/local markets; limited use of cereal banks; use of brokers/middlemen for marketing; value addition for higher prices (improved sorting and packaging) |
| Other potential options to increase farmers' adaptive capacity | Government support to stockists (access drought tolerant seed, early maturing varieties); promote use of certified seeds; diversify to marketable maize varieties (pop-corn maize) | Access to subsidized and mechanized equipment (rippers, sub-soilers); County support for animal training (draught power); access to irrigation equipment; conservation agriculture | Promote modern driers and storage facilities (moisture free); promote community cereal banks; use of solar powered grain driers; mechanization of harvest activities (harvesting, winnowing and sorting) | Promote communal cereal banks; establish grain collection centres; contracted farming; access to crop insurance products |
| Intense rainfall | Shortage of planting seed; limited access to inputs (transport challenges); labour scarcity; high labour costs | Poor seed germination; low growth vigour; reduced agronomic efficiency (fertilisers/applied chemicals); reduced labour efficiency; land preparation challenges; increased weeds prevalence; high labour costs (weeding) | Poor quality of harvested grain; high aflatoxin incidence; challenges in grain drying, shelling and grading; high transport costs; lost of post-harvest value opportunities | Low farmer prices (farm gate prices); market grain scarcity; increased market prices by brokers/traders; loss of market opportunities/linkages |
| Magnitude of impact | Major-Moderate | Major-Moderate | Major-Moderate | Moderate-Minor |
| Farmers' current strategies to cope with the risks | Use of local/recycled seeds; non use of inorganic/organic fertilisers; seed recycling | Soil and water conservation (terraces/furrows/dykes/ grass strips); use of household/community labour (farm rotations); staggered planting; agroforestry; enterprise diversification (root crops/poultry/fishing) | Manual household/hired labour for harvesting, drying, sorting and grading; sun drying (by grain spreading on polythene); manual cob shelling; use of animal transport means; household consumption (low quality grain) | Farmer individual sale (farm gate/local markets); value addition for higher prices (improved packaging); use of alternative marketing platforms (phones/local media); grain hording (improve market prices) |
| Other potential options to increase farmers' adaptive capacity | Sensitizing stockists (access to certified/improved seeds); provision of seed reliefs (County/national government) | Community soil and water conservation, catchment and drainage (canals/tree planting/dams/dykes); promote use of Early Warning Systems; extension advisories on crop management | Promote solar powered grain driers and shellers (at farm level); establish community cereal banks (storage reserves/seed banks); improvement of rural access roads (County support) | County support (improved market structures and facilities); formation of farmer cooperatives (facilitate marketing); community cereal banks; access to crop marketing insurance packages |

# Sorghum

| | Provision of seeds and other inputs | On-Farm production | Harvesting storage and processing | Product marketing |
|---|---|---|---|---|
| Intense rain | Limited access to inputs (transport/terrain challenges); limited labour requirements; increased seed spoilage (pre-germination, rot) | Late planting; logging and leaching of nutrients; poor germination and establishment; increased labour requirements; challenges in land preparation; pests and diseases incidence | Delayed/ irregular harvesting; challenges in harvesting/winnowing/packaging (high moisture); transportation challenges (field to storage); increased post-harvest losses and aflatoxins contamination | Low market supply (scarcity and high demand); low farmer sale prices (low quality); shift in market focus (to other cereal legume commodities); loss of market linkages, information and marketing opportunities |
| Magnitude of impact | Severe-Minor | Severe | Severe-Moderate | Moderate-Minor |
| Farmers' current strategies to cope with the risks | On-farm water control structures (terraces/furrows); use of certified seeds; non-use of inorganic fertilisers and pests/diseases control substances | Early ploughing/planting (before rains); access to weather advisories (plan planting dates); intercropping (root crops); agroforestry; conservation agriculture; ridge and contour planting; manual weeding | Sun drying of moist seeds, seed sorting (remove rot/germinating seed); storage in gunny bags/clay pots; local transport (donkeys/carts) to ferry produce from farms; continuous seed spreading to facilitate drying | Seed hoarding to increase market prices; sale of seed locally and at farm gate; use of brokers/middlemen for marketing |
| Other potential options to increase farmers' adaptive capacity | County support to establish drainage structures (canals/dams) | County support to access mechanized equipment at affordable prices; enterprise diversification (cassava, sweet potato, bee keeping, poultry); promote agroforestry | Establish raised produce collection structures in farms (drying before storage); access to solar driers (grain drying) | Formation of farmer groups (collective bargaining); County support to explore external markets and repair damaged road infrastructure |
| Dry spell | Limited access to inputs; limited labour requirements | Challenges in ploughing, planting); low germination and establishment; low fertilisers efficiency; high labour costs; increased seed loss (by pests/diseases); reduced labour requirements and efficiency (time consuming) | Low quality (very light) and poor harvest quantities; high harvest losses (Low density leading to high spoilage); increased post harvest pests/rodents damage | Reduced farmer prices (low quality); increased trader prices (scarcity); reduced /poor market activities/linkages; divert produce to local markets and household consumption; reduced household income |
| Magnitude of impact | Moderate-Minor | Severe-Minor | Minor | Major-Moderate |
| Farmers' current strategies to cope with the risks | Access to drought tolerant seed varieties; non-use of inorganic fertilisers at planting | Early manual land preparation; dry planting; employ watchers (bird damage to crop); enterprise diversification (fishing/poultry farming); crop ratooning; intercropping (cereals); conservation agriculture | Early harvesting (reduce pest and rodent invasion); IPM during storage; produce storage in gunny bags (reduce spoilage) | Produce hoarding (to increase prices); sale at farm gate and locally (markets/households); sale to brokers/middlemen (breweries agents); sale to animal feeds brokers |
| Other potential options to increase farmers' adaptive capacity | Explore seed priming technologies; use of improved sorghum varieties (drought resistant); access to irrigation facilities | County subsidized mechanization (aid planting, harvesting); drip irrigation; capacity building on proper planting, weeding and ratooning; conservation agriculture; agroforestry (wind breaks); audible bird scaring devices | Mechanized harvesting (reduce harvest losses); access to rodent free storage structures; encourage use of oxcarts (reduce spoilage); access to improved storage bags (PIC bags) | Formation of farmer groups/societies (collective marketing/bargaining); County support to explore external markets; explore traditional value addition products (beers); contract farming (breweries) |

# Beans

| | Provision of inputs | On-Farm production | Harvesting storage and processing | Product marketing |
|---|---|---|---|---|
| Heat stress | Reduced seed viability; reduced demand for inputs; reduced input access (low supply); increased costs of inputs due to scarcity | Poor seed establishment and growth vigour; increased production costs (land preparation); reduced efficiency in labour and fertilisers applied | Increased incidence of storage pests/rodents; poor harvest quality and low quantity; labour scarcity and increased cost | low market supply (scarcity and high demand); reduced farmer prices (low quality); reduced market/marketing opportunities; shift in market focus (cereal/legume commodities) |
| Magnitude of impact | Major-Minor | Moderate-Minor | Minor | Minor |
| Farmers' current strategies to cope with the risks | Use of recycled seed; seed access through farmer-farmer networks; non use of inputs (fertilisers/chemicals); use of drought tolerant bean varieties; seed drying; mechanical scarification | Early planting; use of organic fertilisers (poorly decomposed); enterprise diversification (horticulture/cereals/root crops); access to weather advisories (plan planting dates); agroforestry; reduced tillage | Manual harvesting, sorting, threshing and winnowing (household/hired labour); divert produce to household consumption; seed storage in granaries/gunny bags; use of local preservatives (ash) for pest control | Local and farm gate sales; contracted sales and marketing ( institutions/ external markets); sorting, grading and packaging in determined volumes; sale to brokers/middlemen for external marketing |
| Other potential options to increase farmers' adaptive capacity | Seed pre-germination (priming) | Promote mulching and soil cover; irrigation systems: promote access to extension information and weather advisories | Mechanization of harvesting, threshing and winnowing; promote value addition (tinning); access to improved storage structures (pest free structures) | Use of standardized market weights (kg instead of volumes); county support to access external markets; access to crop insurance products (cushion against loss) |
| Droughts | Labour scarcity; high labour costs; reduced demand for inputs (seed/fertilisers) | Deteriorated soil quality (low organic matter, microbial activity); challenges in ploughing; delayed planting; poor germination and crop vigour; reduced use and efficiency of fertilisers | Poor quality and low quantity of harvested produce; reduced processing costs; loss of value addition opportunities | Reduced farmer prices (low quality); increased trader prices (scarcity); loss of market activities/linkages; reduced activity of farmer associations |
| Magnitude of impact | Major-Minor | Major-Moderate | Minor | Minor |
| Farmers' current strategies to cope with the risks | Mechanization of land preparation activities (oxdrawn ploughs); retain crop biomass (conserve moisture); planting drought tolerant and certified seed; use of traditional seed supply systems (farmer-farmer) | Timely agronomic operations (planting, spraying, weeding); agroforestry; enterprise diversification; water harvesting; mechanization of farm operations; labour hiring; intercropping; conservation agriculture | Seed storage in local structures (granaries/within households); divert harvest to household consumption; use of pots/gunny sacks for seed storage; use of ash for pest control | Local and farm gate sales; contracted sales and marketing (local institutions); sorting, grading and packaging in determined quantities; sale to brokers/middlemen for external marketing |
| Other potential options to increase farmers' adaptive capacity | Access and promotion of certified seeds; access to information (seed preservation, dressing and pest control); diversify planted bean varieties (to marketable varieties) | Adoption of greenhouses; access to weather advisories; establish community owned farm machineries (jab planters, harvesters); conservation agriculture; cultural weed control methods; drip irrigation | Improvement of harvesting, sorting and grading equipment (reduce losses); improved post harvest handling (sorting, grading); explore bean value addition products (drying, roasting, tinning) | Use of standardized market weights (kg instead of volumes); county support to access external markets; access to crop insurance products (cushion against loss) |

# Policies and Programmes

Several national and local policies and programmes have been developed to address climatic and broader vulnerabilities in the County.

*The Environment Management and Coordination Act (EMCA 2015).* The environment is intertwined with the survival and socio-economic well-being of the population who depend directly and indirectly on environmental goods and services. Climate change has adverse impacts in the form of floods, landslides, and prolonged drought which pose a significant challenge to manage. Therefore, the objective of the policy is to provide a framework for an integrated approach to planning and sustainable management of Kenya's environment and natural resources. The policy therefore provides a legal and institutional framework for good governance, effective coordination and management of environmental and natural resources.

*The Kenya Forest Service Act (Forest Policy)*. This policy ensures that measures are put in place to significantly increase the area under forest cover with the aim of attaining the national target of 10% area under forest cover. To attain this objective, the government is promoting farm forestry, intensifying dryland forestry management and also promoting community participation in forest management and conservation. The policy stresses the need for greater cooperation and linkage among resource owners, and users, and resource planners.

The Kenya Forest Service (KFS) and non-governmental organisations such as VI Agroforestry and Welthungerhilfe have been spearheading on-farm planting of trees such as Grevillea robusta and fodder trees such as Calliandra, Sesbania and Leucaena to increase the tree cover and generate income. The use of energy-saving jikos is being scaled up in the County by the KFS and other non-governmental actors to tame the rampant felling of trees that is witnessed in the County. In relation to the aforementioned activities, income-generating activities such as beekeeping and handicraft weaving have been introduced to farmers as alternative sources of income. The purpose was to dissuade them from rampant charcoal burning which is a major challenge in tackling climate change and environmental degradation.

*The Water Act (water policy)*. This policy takes cognisance of the contribution of water resources to economic productivity and improvement of livelihoods. The objective is to promote optimal, sustainable and equitable development and use of water resources as livelihoods of Kenyans. One of the ways to ensure this objective is achieved is by progressive restoration and protection of ecological systems and biodiversity in strategic water catchments. This is done by reforestation and restoration of biodiversity. This can also be achieved through promoting rainwater harvesting and storage systems. However, water availability and water service provision do not develop at the same pace with agricultural production.

The Water Resource Management Authority (WRMA) has formed the Water Resource Users Association (WRUAs) to help in the management of the catchment areas from the upper to the lower basins. To this end, WRMA is building the capacity of WRUAs. To achieve optimal use of water, water harvesting is being encouraged through roof water harvesting, damming rivers and storing water, and construction of water pans on-farm to store water for future use in addition to protecting water springs. The WRUAs are also involved in afforestation activities and thus help protect the water catchment. In addition, the income-generating activities such as pig keeping, poultry, dairy goats, bee-keeping and horticulture have been introduced in the basins so that the residents can help conserve them. This is meant to dissuade the residents from using the riparian land and hence bringing about environmental degradation.

*The Irrigation policy.* The policy recognises the fact that Kenya has not fully developed her irrigation potential. By the end of 2013, about 10% of the irrigation potential had been realised, leaving more than 90% undeveloped. It is through this realisation that Siaya County through Lower Nzoia Irrigation project has been spearheading irrigation activities to increase the area under irrigation and increase production of irrigated agriculture along Rivers Nzoia and Yala.

Even though not directly dealing with climate risk management, a number of projects have been active in improving agricultural productivity in Siaya County. These include: Njaa Marufuku Kenya (NMK), Traditional High Value Crops (THVCs), East Africa Agricultural Productivity Programme (EAAPP), Rice Promotion, Kenya Agricultural Productivity and Agribusiness Project (KAPAP), Private Sector Development in Agriculture (PSDA), Agricultural Sector Development Support Programme (ASDSP), Millennium Village project and Water Harvesting for Food Security project.

Horticultural crop production in the County is gradually picking up due to the sensitization efforts made by the MoA, Department of Irrigation and Drainage (DID), which is assisting in rehabilitating the old irrigation schemes and

establishing new ones along the Lake Victoria shores and River Yala. The National Irrigation Board is engaged in the initiation of the lower Nzoia irrigation scheme which covers Ugunja, Ugenya, and Alego Usonga sub-counties. The Smallholder Horticulture Promotion Programme operating in four sub-counties namely: Alego Usonga, Gem, Ugenya, and Bondo has been promoting growing of kales and tomatoes for income generation.

The World Bank-funded Western Kenya Community Driven Development and Flood Mitigation Programme (WKCDD&FMP) under the Ministry of Special Programmes has also enhanced uptake of technologies such as greenhouse and micro irrigation to help farmers become less reliant on rain-fed agriculture.

ASDSP is complementing the efforts mentioned above by promoting mango production as one of its selected priority value chains and supported by the Kenya Agricultural Productivity and Agribusiness Programme (KAPAP). KAPAP ventured in production of fruits, local poultry and fish as key value chains. The main fruit crops grown are mangoes, paw paws and bananas.

## Governance, institutional resources, and capacity

Climate risk management and adaptation strategies are implemented mainly through collaboration between various state and non-state actors. The state actors include the line ministries and departments such as; Agriculture, Livestock and Fisheries department, ASDSP, the KMD, the KFS together with its research arm, the Kenya Forestry Research Institute (KEFRI), and government parastatals such as National Environmental Management Authority (NEMA). The non-state actors include NGOs such as World Vision (WV), Red Cross, Food, World Food Programme (WFP), Welthungerhilfe, PLAN Kenya, and CARE Kenya. Government departments mainly provide the technical support and policy direction while the non-state stakeholders provide the research, funding, and implementation for the adaptations. The collaboration is largely through a stakeholder's forum which is responsible for planning climate risk management.

In Siaya County, the ASDSP, a government programme, is the key player that spearheads climate risk management by convening a stakeholders' meeting that brings together both the state and non-state actors. ASDSP does the coordination through a stakeholders meeting known as Participatory Scenario Planning (PSP) providing contingency planning for climate risk management. The stakeholders meeting assesses the situation based on the EWS provided by the KMD and the flood risk management office and comes up with the intended solutions. Each actor is apportioned their task to perform based on their capacity and financial resources at their disposal. For instance, in 2014, the Kenya Red Cross (KRC) through the disaster management programme implemented the Siaya Integrated Food Security and Livelihoods Project which benefitted 48,000 farmers towards becoming resilient to future shocks. The NGOs have a high influence in the implementation process due to their financial muscle. The assessment is done for both the Long and the Short rains and in case of any other emergency. Community-based organizations are normally incorporated in implementation of adaptations since they are founded in the grassroots and are able to influence many farmers within their reach.

Although there is a lot of collaboration among the various stakeholders mentioned above in managing climate risks to agriculture, several challenges are apparent. Low technical, financial and human resource capacity has hampered efforts to manage climate risks to agriculture. This is heavily influenced by insufficient budgetary allocations for the various state actors involved in climate risk management in the County. Departments like KMD, Agriculture, Livestock, and NEMA are insufficiently staffed. This hinders implementation and monitoring of activities like determining whether farmers make use of the early warning information that is disseminated. For instance, the National Drought Management Authority (NDMA), a key player in drought management in the country, does not have an office in Siaya County, despite the high incidence of drought risks in the area. Currently, the KMD is poorly equipped, having only rain gauges and hence recording only rainfall, which is not adequate for downscaling. The department also engages volunteer community rainfall observers or monitors to collect rainfall data. Ideally, automatic weather stations would have been preferred.

There are no County-specific policies or guidelines on enforcing climate change policies. The existing institutions act in isolation and there is no mechanism to coordinate interventions and deliver support. On the other hand, institutions that offer extension lack preparation on emergency risk response.

Inadequate funding and limited human capacity are barriers to effective climate risk management. They affect planning and implementation and thus need to be addressed. Different organizations, especially the NGOs involved in climate risk management, should share

information to avoid duplication and improve efficiency in implementation. There is need for the various stakeholders involved in climate risk management to be trained on climate risk management to enhance their skills for choice of adaptations. There is also need for adequate monitoring and evaluation of interventions to improve the efficiency of implementation of climate risk management adaptations. There should be more forums of engagement between the various stakeholders involved in climate risk management to share information and increase implementation efficiency so as to benefit as many people as possible. This can be achieved through increased funding for climate risk management.

## Synthesis and Outlook

Agriculture is the mainstay of the Siaya County in addressing food security and livelihoods of the population. However, the sector is beset by a myriad of challenges that are exacerbated by climate variability and change, making the residents vulnerable. Drought and flooding incidences are presently evident and are bound to increase in the near future in Siaya. The County therefore requires adaptive strategies to cope with climate change to ameliorate the risk posed by climate change.

A variety of measures to increase the resilience of farmers in Siaya are currently ongoing. They include on-farm practices such as planting drought-resistant varieties, crop diversity through introduction of other drought-tolerant crops, construction of water pans, Zai pits, terracing aiming at water and soil conservation, drip irrigation, mulching, crop rotations, agroforestry systems, and drought-resilient animal breeds. To complement the on-farm services, there are off-farm activities such as the early-warning information and extension services to prepare and advise farmers on how to manage the risks. Other farmers have formed groups that provide cheap agricultural labour to one another.

Farmers decry the dearth of accurate weather forecast information. Since information is a key ingredient in making informed decisions, it is important that farmers have access to timely and accurate weather forecast information. For this to be realized, the capacity of the KMD can be enhanced through the acquisition of automatic weather stations. This is to improve the efficiency of downscaling weather forecasts that measure an array of parameters which, when combined, give accurate weather forecast information. Recommended inputs should be made available at the right time through availability of more input outlets.

Farmers in the County rely on rain-fed agriculture. Irrigation offers a huge potential for the future of agriculture in the County. The potential of irrigation can be harnessed with a 153 km of shoreline with Lake Victoria that is untapped together with River Nzoia and Yala basin through drip irrigation. This can be complemented with other water-harvesting techniques such as water tanks, ZAI pits, and water pans. Farmers are already taking cognisance of the fact that there are climate change risks and have already started taking measures to address them. Efforts should be made to upscale technologies such as conservation agriculture, soil and water conservation, tree planting, and diversification of enterprises.

Introduction of drought-tolerant crops such as sorghum offers a glimmer of hope to the farmers in the County. Efforts by EABL to engage the farmers in contract farming of sorghum should be enhanced by casting the net far and wide to incorporate more farmers especially in the LM4 and LM5 agro-ecological zones and increase the acreage under sorghum. This can be done through provision of the necessary support to farmers in the form of inputs and extension services.

Investments in the provision of basic amenities such as availability of and access to electricity, water, health facilities, and education are required to empower farmers and help them takeinformed decisions on their farms (such as use of inputs and interpreting weather information). These services also provide avenues for the populace to engage in alternative income-generating activities and thus increase their resilience.

Even though a number of multiple actors are involved in various activities addressing food security challenges, there seems to be a cleavage and an overlap of activities among the actors. Therefore the involvement of the multiple actors should be enhanced and structured to improve on the efficiency of implementing climate risk adaptations. Sharing of information should be a key pillar in the collaboration of the multiple actors for proper coordination to be realized.
Last but not least, there is need to scale down national policies to the County level and tailor them to the needs of the County. Climate risk management needs to be embedded in County development plans, with adequate budgetary allocation, to avoid unstructured reaction and uninformed decisions when hazards occur.

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

**Annex 1:** Production of key crops and livestock in Siaya County
**Annex 2:** Agricultural value chain commodities key for food security in Siaya County
**Annex 3:** Climate adaptation options in Siaya County as highlighted in ASDSP

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