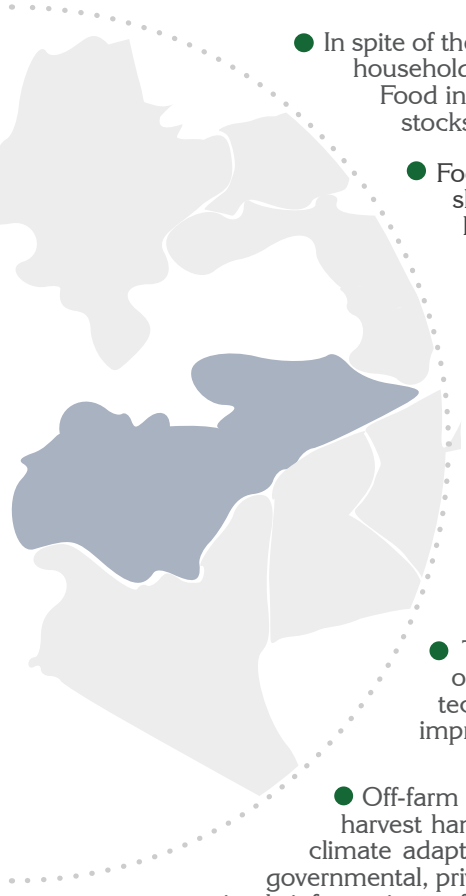
Climate Risk Profile
Homa Bay County

Highlights



- About 74% of the labour force is employed in agriculture. Most of the household income is derived from crop, livestock and fishery activities. Adult men receive more income from on-farm activities compared to adult women and youth. Fishing and agriculture also play a crucial role in household food and nutrition security.

- In spite of the overreliance on agriculture, half of the population is food insecure. The overall proportion of households who do not have enough food to meet their household needs throughout the year is 82%. Food insecurity peaks between July and August and between December and March when harvested stocks have been depleted.

- Food insecurity is linked to low productivity due to factors such as extreme weather, climatic shocks, unsustainable natural resource management, high prevalence of HIV/AIDS (21.7%) and limited access to farm inputs. Water availability is also a limiting factor in crop and livestock production. Only 13.3% of the land under irrigation, despite the County's huge potential to irrigate as it borders the largest freshwater lake in Africa, Lake Victoria.

- Looking to the future in the years of 2021-2065, 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 0.7% in the first wet season, and 3% in the second wet season. Prolonged moisture stress is projected to occur in the first season of the year, whereas intense precipitation looks to change little in either season.

- Consecutive days of moisture stress is projected to almost double in the first wet season (January – June) from approximately 25 days to around 45-50. In contrast, moisture stress in the second wet season (July – December) is projected to decrease from 60 consecutive days of moisture stress to approximately 50 days.

- To cope with climate change and variability, farmers in Homa Bay County are using a number of on- and off-farm adaptation strategies. On-farm strategies include: soil and water conservation techniques, adoption of early-maturing varieties, staggered planting, post-harvest handling, improved storage facilities, and value addition.

- Off-farm services, such as early warning systems, extension, capacity building and training, post-harvest handling and storage facilities and market information, are offered to farmers to increase their climate adaptive capacity. Such services are offered by a variety of actors such as governmental, non-governmental, private, faith-based and international organizations. However, the capacity to deliver relevant and timely information to farmers throughout the County is constrained by coordination of interventions, infrastructure, and a lack of human and financial resources.

KAPP
Kenya Agricultural Productivity Programme
Republic of Kenya
WORLD BANK GROUP

List of acronyms

AEZ	Agro-Ecological Zone
AMCS	Aquaculture Multipurpose Cooperative Society
ASDSP	Agricultural Sector Development Support Programme
BMU	Beach Management Unit
CEAP	County Environmental Action Plans
ECF	East Coast Fever
EMCA	Environmental Management and Coordination Act
FES	Friedrich-Ebert-Stiftung
FFS	Farmer Field Schools
FSI	Forest Social Initiative
GEF	Global Environmental Facility
ICIPE	International Centre of Insect Physiology and Ecology
ILRI	International Livestock Research Institute
ITOC	ICIPE Thomas Odhiambo Campus
KACCAL	Kenya Adaptation to Climate Change in Arid and Semi-Arid Lands
KALRO	Kenya Agricultural and Livestock Research Organization
KAPP	Kenya Agricultural Productivity Program
KDA	Kenya Department of Agriculture
KFS	Kenya Forest Service
KIHBS	Kenya Integrated and Household Budget Survey
KLD	Kenya Livestock Department
KMD	Kenya Meteorological Department
KDVS	Kenya Department of Veterinary Services
LBDA	Lake Basin Development Authority
LPVCCS	Local Poultry Value Chain Cooperative Society
LVEMP	Lake Victoria Environnemental Management Program
MoALF	Ministry of Agriculture, Livestock and Fisheries
NCCAP	National Climate Change Action Plan
NCPB	National Cereal and Produce Board
NCCRS	National Climate Change Response Strategy
NEMA	National Environmental Management Authority
NIE	National Implementing Entity
PVVCS	Peanut Value Chain Cooperative Society
RDCS	Rangwe Dairy Cooperative Society
SCCF	Special Climate Change Fund
SEA	Sustainable East Africa
USAID	United States Agency for International Development
VCC	value chain commodity
WB	World Bank

Foreword

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

In 2010, Kenya developed a National Climate Change Response Strategy (NCCRS) which recognized the importance of climate change impacts for the country's development. This was followed by the development of the National Climate Change Action Plan (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 this effort to strengthen local capacities of stakeholders to reduce the near-, medium- and long-term vulnerability to current and future climate variability, the Kenyan Government, through the Ministry of Agriculture, Livestock and Fisheries (MoALF) is implementing the Kenya Adaptation to Climate Change in Arid and Semi-Arid Lands (KACCAL) project. The project is funded with a grant from the Global Environmental Facility (GEF) / Special Climate Change Fund (SCCF) through the World Bank (WB). The present study is part of the KACCAL project. It aims to inform the County Government and stakeholders on the climate change risks and opportunities for agriculture so that they are able to integrate these perspectives into their development plans and processes.

This document presents the Climate Risk Profile for Homa Bay County, where climate variability has been accompanied by a significant increase in attendant risks, as often reported in national news. In recent years, flash flooding has triggered mudslides and repeatedly caused major rivers to overflow their banks, leading to displacement and even death. In 2015, rivers Maugo, Awach Tende, Rangwe and Riana overflowed destroying homes and reclaiming farmland on more than 300 farms. That same year, seven people were lost to floods and landslides in Homa Bay County alone. The effects of the flash floods were compounded by the fact that the County had faced more than two years of persistent drought that compromised human and agricultural water sources, forcing the most affected residents in Kojwang to travel over two dozen kilometers to collect water. The drought saw hundreds of livestock, particularly cattle and donkeys, to perish and led to outbreaks of waterborne diseases, especially in Karachuonyo. Measures to address these threats have included handling vaccines, partnering with World Vision to improve water harvesting and de-silt water pans; working with state researchers to introduce drought-tolerant millet crossbreeds; state-sponsored distribution of drought tolerant crop seeds. The disastrous nature of extreme weather makes the identification of impending climate risks an urgent matter. Likewise, considering how practices that help citizens become more resilient in the face of imminent threats to their health, safety, and livelihoods becomes an exercise with the potential to affect hundreds of thousands of lives.

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

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 even more in the future. In many areas, extreme events and variability of weather are now the norm: rainfall is irregular and unpredictable; some regions experience frequent droughts during the long rainy season, others severe floods during the short rains. The arid and semi-arid areas are particularly hard hit by these climate hazards, thereby putting the lives of millions of households and their social and economic activities at risk.

1 As reported by online newspaper (Floodlist, 2015).
2 As reported by Daily Nation online newspaper (Daily Nation, 2014).
3 As reported by Daily Nation online newspaper (Daily Nation, 2015).

Agricultural context

Economic relevance of farming

The County of Homa Bay covers an area of 4,267.1 Km2 and is located in south western Kenya along Lake Victoria, the largest freshwater lake in Africa with a surface area of 1,227 Km2. Homa Bay County borders Kisumu and Siaya Counties to the north, Kisii and Nyamira Counties to the east, Migori County to the south and the Republic of Uganda to the west. The County has 16 islands, with unique fauna and flora and an impressive array of physiographic features with great aesthetic value of nature. Because its proximity to Lake Victoria, fishing is one of the main activities together with agriculture.

Agricultural activities in the County vary with the Agro-ecological Zones (AEZs). The County is divided into several (AEZs), namely:

- The upper midlands (UM1) occupy the southern parts of Kasipul and Kabondo Kasipul Sub Counties where tea and coffee are grown.
- The upper midlands (UM3) cover the Gwassi hills of Suba Sub County. Maize, millet, pineapples, sorghum, sunflower and tomatoes grow well here.
- The upper midlands (UM4) cover areas surrounding Gwassi hills of Suba as well as Ndhiwa and Nyarongi areas of Ndhiwa Sub County. It supports maize, soya beans and pineapples.
- The lower midlands (LM2) occupy parts of Ndhiwa, Homa Bay Town, Rangwe, Kasipul and the north of Kabondo Kasipul Sub Counties. This zone supports green grams, millet, sorghum, tobacco, sunflower, sugarcane, beans, pineapples, sisal and groundnuts.
- The lower midlands (LM3) occupy parts of Homa Bay Town and Rangwe sub-counties. It is suitable for growing maize, sorghum, cow peas, ground nuts, beans, soya, sweet potatoes, sunflower, simsim, green grams, rice and vegetables.
- The lower midlands (LM4) occupy a strip along east of Karachuonyo, central Mbita and Gwassi areas of Suba Sub County. The area is suitable for growing cotton.
- The lower midlands (LM5) occupy south-west Suba, Rusinga and Mfangano islands, Lambwe Valley and Gembe and Kasgunga areas of Mbita Sub County. The area supports livestock rearing and millet growing.

Agriculture is the leading income contributor to the households and it plays a crucial role to food and nutrition security in Homa Bay County. According to the 2009 Kenya Population and Housing Census, the employed population in the County stood at about 393,374 representing about 79.5% of the labour force of which 74% are employed in the agricultural sector. In 2012, the County earned about KES 4.1 billion from the major crops, with maize and beans contributing about KES 2 billion and KES 0.9 billion, respectively. Maize and beans account for 74% of the estimated income from the main crops (GoK, 2014) (Annex 1).

The value estimations for horticulture are higher than for other crops since they have higher gross profit margins per hectare. In the fiscal year 2012-2013, 322,290 tons of cash crops valued at KES 1.18 billion were produced. The main cash crops grown in the County include cotton, sugarcane, rice, pineapple, sunflower and ground nuts. Coffee and tea are also marginally produced in the upper zones of the County.

Milk and beef generated KES 1.8 billion and KES 783 million, respectively. The main livestock kept in the County include zebu cattle, the red Maasai sheep, the small East African goat and indigenous poultry. Annex 2 presents information on the quantity and value of livestock products generated in the County.

Most of the income is derived from crop, livestock and fishery activities. Adult men receive more income from on-farm activities compared to adult women and youth. On-farm income earns the households an average of KES 98,496. Crop income represents 40% of all on-farm income and livestock represents 21%. Woodlot activities earn male-headed households an extra KES 19,050 per year and female-headed and youth-headed households KES 7,600 and KES 3,733 per year, respectively (GoK, 2014) (Annex 3).

Fishing forms a major economic activity in the County, as the County borders Lake Victoria, generating annual revenues of approximately KES 7 billion. It is a prominent activity in the County, engaging over 18,300 people and 3,600 families. The main species caught include Nile perch, tilapia and clarias (Omena). In 2012, 76,710 tons of fish worth KES 7 billion were

4 The labour force is the economically active group of the ages 15-64 that is greatly depended upon by ages 0-14 and those above 64 years

captured. Of these, Nile perch contributed KES 5 billion and clarias contributed KES 1.7 billion. Aquaculture is relatively underdeveloped in the County. Around 1,801 fishponds covering an area of 540,300 square meters (m2) are found. In 2014, 783 tonnes of farmed fish valued at KES 159,554 million were produced in the County (GoK, 2015).

People and livelihoods

According to the 2009 census, in 2012, the population was projected to be 1,038,858 persons (498,472 men and 540,386 women). The population is expected to rise to 1,177,181 by 2017. Rural population from the 2012 projections stands at of 956,501 which is about 92% of the total population of the County. About 44% of this rural population are poor. (GoK, 2013).

About 50% of the population of Homa Bay County is food insecure (GoK, 2013). The overall proportion of households who do not have enough food to meet their household requirements throughout the year is 82%. Among the male-, female- and youth-headed households at least 82%, 81% and 84% of households do not have enough to meet the household needs[5]. (GoK, 2014)[6] Food insecurity peaks between July and August and between December and March, when food stocks have been depleted.

The manifestation of malnutrition among children is in the high incidences with prevalence of stunting 26.3%, underweight 15%, and wasting 4.2%. According to the Kenya Integrated and Household Budget Survey (KIHBS) the absolute poverty level in the County is 52.9%, higher than the national level of 45.2%. The major factors which contribute to poverty are: high unemployment, high cost of living, population pressure, poor yields, low price of agricultural produce, poor infrastructure, and lack of credit and high incidence of HIV/AIDS. The majority of the poor are women and youth. The literacy rate in the County stands at 64% with men accounting for 66%, women 54% and youth 74%.

Agricultural activities

As indicated above, the great majority of the County`s population is employed in agriculture, dividing their activities between crop production, livestock rearing, and fishery. About 104,464 hectares are dedicated to food crops, 12,277 hectares to cash crops, 6,000 hectares to horticulture and 54 hectares to aquaculture.

The main food crops produced in the County include maize, beans, sorghum, millet, kales, sweet potatoes and peas. The vast majority (80%) of the farmers grow maize and beans (GoK, 2014). The main livestock kept in the County include zebu cattle, the red Maasai sheep, the small East African goat and indigenous poultry. Most of these livestock are bred for their sentimental value and are used only in emergencies to cover medical and transport costs, pay school fees, entertain guests and pay dowry. There is limited grazing land available in the County and thus limited commercial development of livestock. (GoK, 2013). This explains the lack of group and company ranches.

The mean land holding size in Homa Bay County stands at 6 acres (around 2.4 hectares). On average, 2 acres are used for settlement and the remaining 4 acres is used for agricultural and rural development purposes. The average farm size for small-scale farmers is 4 acres while that of large-scale farmers is 10 acres. The large-scale farmers are found mainly in the less densely populated areas of Ndhiwa, Suba and Mbita Sub Counties where large stocks of livestock are kept. These are in the lower midland AEZ (LM5). The main crops grown on large-scale farms are maize, sorghum, beans and agroforestry systems. Smallholdings are prominent in the densely populated areas (UM1, UM3, UM4, LM2) of Homa Bay Town, Rangwe, Kasipul and Kabondo Kasipul where the main crops grown are maize, beans, pineapples, groundnuts and potatoes. (GoK, 2013).

The percentage of land with title deeds in Homa Bay County stands at about 48%. Most land is communal. Landlessness in the County is estimated at 3%. This is because of land adjudication process and the vast majority of residents are indigenous people with customary rights to hereditary land. The vast majority of the landless are migrants in trading centres and returnees who were forced back in the wake of the post-election violence of 2008. (GoK, 2013).

The three major farm inputs used on annual crops are seed/planting materials, field pesticides and organic manure. The levels of inputs used on annual crops by different households vary between seasons and crop type. Other farm inputs include: storage pesticides, herbicides, top dressing fertiliser and planting fertilisers. The main farm activities in which machinery is used

5 Food security is defined as a state whereby, at individual, household, national, regional and global levels, "all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996)

6 Household food security refers both to the availability and to stability of food, together with purchasing power of the household (GoK, 2014)

Livelihoods and agriculture in Homa Bay

Demographics

2.7% Of Kenya´s population

1,038,858 inhabitants

92% Live in rural areas

52% 48%

Access to basic needs

53% of the population lives in **absolute poverty**

Potable water	35%
Electricity for cooking	0.2%
Electricity for lighting	3%
Education (youth literacy rate)	74%

Food security

50% of the population suffers from **food poverty**

ND of household **income spent on food**

ND People **undernourished**

26% Children **stunted**

4% 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 199,620ha — 63%

74% of the population employed in agriculture production

48% of farmers have title deeds

ND% are women

Farming activities

Food crops 52%

Cash crops 6%

Of county´s agricultural land

Livestock

ND Group ranch

ND Company ranch

Farming inputs

Water uses

ND ND ND

Fertiliser types (% of households)

17% Organic manure

18% Planting fertiliser

6% Top dress fertiliser

Pesticide types (% of households)

1% Field pesticides

4% Storage Pesticides

0% Herbicide

are ploughing (53%) followed by harrowing (35%). Other mechanized activities are planting, carrying/ transportation and milking. The County Government also provides subsidized tractor hire services. There is one tractor in each of the 8 Sub Counties and the charges are KES 3,000 per acre. This is important for early land preparation and avoiding the impact of climate shocks such as dry spells. By April 2016, a total of 2,500 acres was ploughed using tractor hire services. The Kenya Department of Agriculture organizes demonstration blocks in the 40 electoral wards in the County, with each ward growing different crops, based on comparative advantage.

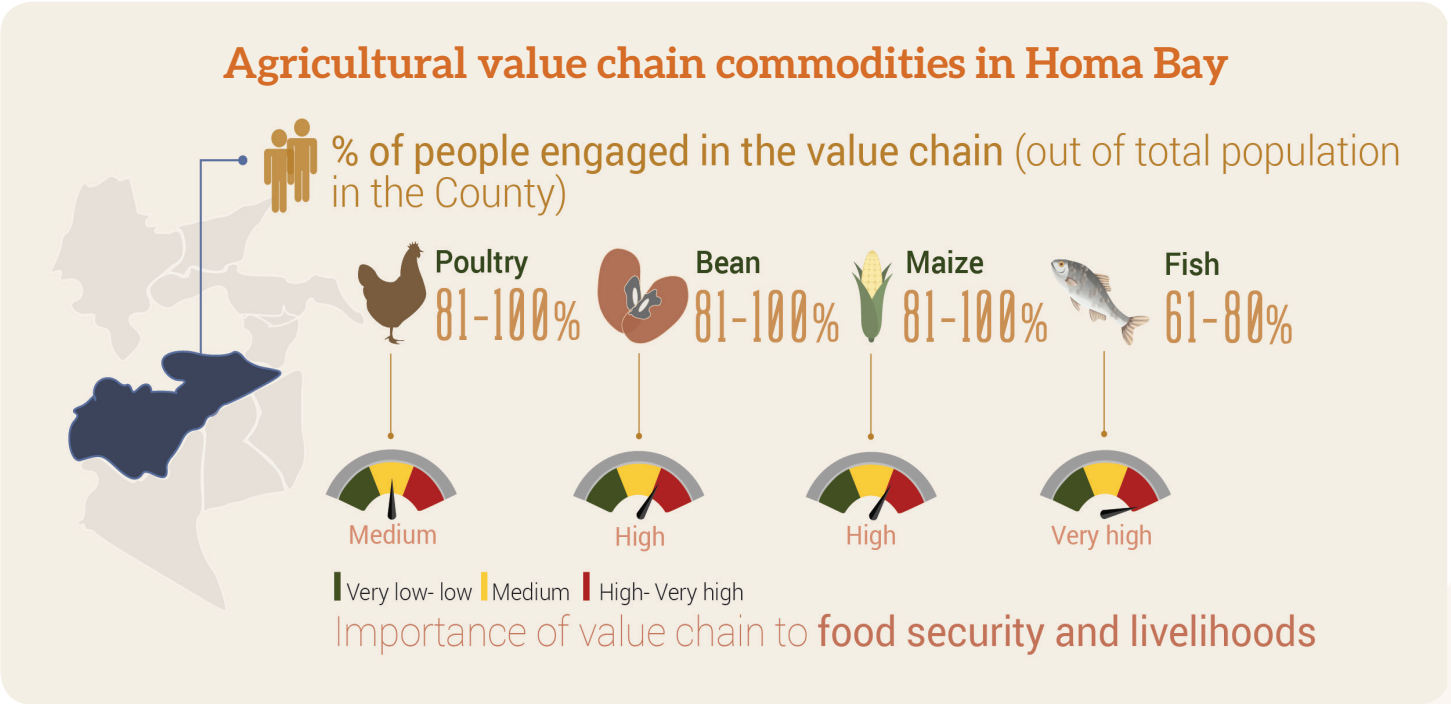
The most commonly used inputs for livestock production include acaricides (38%), dewormers (37%) and vaccines (33%). Less than 1% of farmers use artificial insemination to upgrade livestock. Proportionately, more adult male-headed households use livestock inputs than adult female-headed or youth-headed households. However, more youth-headed households use fodder, vaccines and other veterinary drugs compared to male-headed and female-headed households.

Only 13.3% of the land is under irrigation. Major horticultural crop grown under irrigation include kales, tomatoes, onions, capsicum and watermelon. The County's potential for irrigated agriculture is 8,966 hectares (GoK, 2013).

The County's generally low productivity and yields are associated with low input use, particularly by adult female- and youth-headed households. High cost of agricultural inputs is the main constraint.

Agricultural value chain commodities

Agricultural production in Homa Bay County is characterized by subsistence farming and small-scale production of commercial crops, livestock production, fish farming and capture fishing. Various value chains have been prioritized for development interventions by different government organizations and programs such as the Agricultural Sector Development Support Programme (ASDSP), the Kenya Agricultural and Livestock Research Organization (KALRO) and University of Nairobi survey, and the Kenya Agricultural Productivity Program (KAPP). For the development of this County Climate Risk Profile, four major agriculture value chain commodities (VCCs) were selected for in-depth analysis based on their contribution to food security, productivity characteristics and importance to the economy. These VCCs, validated by local stakeholders, have been selected from a list compiled from the above-mentioned documents using the following prioritization indicators: harvested area (hectares), production (90 kg bags), variation in production (in the past five years), value of production (KES$/bag), dietary energy consumption (Kcal/capita/ day), protein content (gr of protein/100 gr of product),



iron content (mg of iron /100 gr of product), zinc content (mg of zinc/100 gr of product), and Vitamin A content (IU Vitamin A/100 gr of product).

The selected value chains for Homa Bay are maize, beans, fish, and local poultry. Maize and beans were selected mainly for food security because they are staple foods in the County; fish on the other hand and local poultry were selected for economic purposes because of high demand in the market. The rest of this section focuses on the four value chain commodities and the subsequent sections discuss how they are affected by climatic conditions.

Maize

Maize is a major contributor to the household food security and nutrition. The vast majority (80%) of farmers grow maize since it is considered a staple food (GoK, 2013). Maize has comparative advantage in the upper midland zones of the County (UM1, UM3, and UM4) and lower midland zone (LM3). The popular ugali is important in the Luo community, where dry maize is milled to maize flour and cooked to ugali which can be accompanied by vegetables and proteins such as fish and Nyoyo where the maize is mixed with beans. Income from maize production represented 50.84% (KES 2 billion[7]) of the total income from major food crops generated in the County.

Maize is grown in both the first season (March to May) and the second season (October to December) across the County. However in some parts of the County such as Lambwe, the farmers tend to grow maize only once a year (during the second season), due to the unreliable rainfall patterns. Maize requires abundant annual rainfall (1,200-2,500 mm) while rainfall in Homa Bay County is low and unreliable, ranging from 700 to 800 mm. While male-, female-, and youth-headed households alike grow maize on relatively small areas of land, male-headed households tend to use more inputs and register higher yields compared to women and youth. Annex 4 shows yields of major crops in the County by gender. Women, however, tend to use organic manure more than men as it is readily available on farm.

Farm inputs are bought from seed companies and farm input dealers, The National Cereal and Produce Board (NCPB) depot is also responsible for providing farm inputs such as the fertilisers and seeds at subsidized prices. On-farm maize production also involves weeding to ensure pests and weed control to minimize competition and maximize yields. There has been increasing weeds and pests in maize production over the years according to the farmers' testimonials. Such weeds and pests include but are not limited to: parasitic striga weeds, stem borers and stalk borer and storage pesticides such as large grain borer commonly known by the farmers as osama

The main storage facilities in the County include cribs (75% of the farmers use these) and gunny bags (24%). Only 1% of the population appears to use silos. Silos are used mostly by the NCPB at their mini depot in Magunga (GoK, 2013). The Big NCPB depot in Homa Bay Town is not used for storage of produce.

There are no well-defined farmers groups and cooperatives in this value chain, maize is thus sold in most cases at the household level in the local market centres on market days. Major market centres in the County include: Sindo, Ndhiwa, Rodi Kopany, Kosele, Mirogi, Rangwe, Adiedo, Nyangweso, Aora Chuodho, Magunga, Ringa, Kadongo, Chabera, Misambi, Ruga, Nyandiwa, Ogongo and Sena.

Fish

Fishing forms a major economic activity in the County. This is attributed to the fact that the County borders the largest fresh water lake in Africa, Lake Victoria, and has a number of rivers that are important in fishing activities. Homa Bay County has two types of fishing activities: capture fishing and aquaculture.

A total of 17,000 fishermen in the County rely on fishing for their household income. The Riparian Sub Counties that engage in capture fishing include Rangwe, Karachuonyo, Mbita, Suba and Homa Bay Sub County and are located in UM3, UM4, LM3, LM4, LM5 zones. Aquaculture is practiced across the County. Fishing guarantees generation of annual revenues of approximately KES.7 billion. The main species caught include Nile Perch, Tilapia and Clarias (Omena) (GoK, 2013).

In the year 2012, 76,710 tons of fish worth KES 7 billion were captured. Of these, Nile perch contributed KES 5 billion and clarias (Omena) contributed KES 1.7 billion (GoK, 2013).

7 Total income generated from the food crop was 4.1 billion

Capture fishing requires nets and boats as inputs. The Beach Management Unit (BMU), fishermen and Government are involved in the conservation of the breeding sites to protect the fish stock. The County has 151 landing beaches[8] managed under 133 Beach Management Units. (GoK, 2013). These landing beaches have become influential trading centres in the County especially for fish products. Examples of landing beaches which have become thriving trading centres include Nyandiwa, Ringiti, Remba, Kwethumbe, Alum, Kaugege, Ndhuru and Sena. There are no fishing groups, or cooperatives in the County.

The main challenge in this value chain are invasive species such as the recurrent water hyacinth, hindering fishing and depriving the lake of oxygen, overexploitation affecting the fish stock, exploitation by middlemen.

Aquaculture is relatively underdeveloped in the County, even though it is practiced across the County. In all, 1,801 fishponds are found in Homa Bay, covering an area of 540,300 m^2. There are about 2,000 fish farmers involved in aquaculture. Fingerlings, fishponds, feeds and fishing nets are key inputs required by farmers in this value chain.

In aquaculture, there are fish farmer groups as well as a cooperative, also known as Homa Bay County Aquaculture Multipurpose Cooperative Society (AMCS). The presence of the cooperative helps in linking buyers and sellers, pricing and the promotion of the value chain. Other actors that play a role in marketing are middlemen and BMU's. Fish farmers use cooler boxes to store their fish.

Homa Bay County is home to two fish processing industries in Homa Bay Town and Mbita Point from which fish produce is exported to other counties as far as Nairobi County (GoK, 2013). Processing enhances the quality and increases the shelf life of fish.

Bean

Beans are a staple food in the County and are grown in both seasons by a vast majority (80%) of farmers across the County (GoK, 2013). Beans thrive well in AEZs UM4, LM2, LM3. Incomes from bean production represented 23% (Ksh 0.9 billion) of the total income from major food crops generated in the County (GoK, 2014).

Beans grow at temperatures that range between 17.5 and 27°C. The temperatures in the County range from 17.1°C to 34.8°C (GoK, 2013). Beans require a moderate, well-distributed rainfall of 900-1200 mm per annum, however, dry weather during harvest is very important. Irrigation is important to maintain a continuous production. However, rainfall in Homa Bay is low and unreliable; the County receives an annual rainfall ranging from 700 to 800 mm.

Suitable soil type for growing beans range from light to moderately heavy to peaty (with organic matter) soils with good drainage. This is not quite the scenario in Homa Bay County, hence the need for fertilisers to increase the soil fertility. Farm inputs are bought from seed companies and farm input dealers in market centres, The NCPB depots in Homa Bay and Kendu are providing farm input such as fertilisers and seeds at subsidized prices. Some farmers also use pesticides to achieve pest and disease control for high output.

Post-harvest activities refer to threshing and winnowing to add value, packaging, dusting and storage to lengthen beans' shelf life. Most of the farmers (75%) use cribs and gunny bags (24%) for storage (GoK, 2013).

The prices of beans are determined by the market forces of demand and supply and there are no cooperatives in this value chain. Thus, bulking, bargaining power, accessibility of trade facilities and setting of prices is compromised. Beans are sold at the household level at local and major market centres. Annex 4 shows the yield of beans by season and gender. Male-headed households tend to use more inputs and register higher yields. Men dominate in decision-making for market-oriented crops such as beans and others such as green grams, kales, and maize. However, the role of women is more prominent in groundnuts and sweet potatoes which are also market oriented (GoK, 2014).

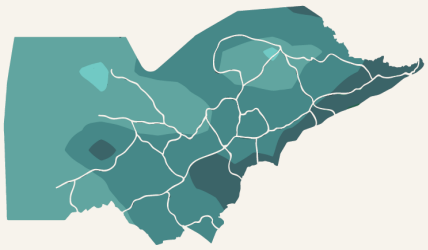
Poultry (local)

In almost every household, indigenous chickens freely roam around homesteads and scavenge for food with very little supplementary feeding and minimal additional inputs, such as sorghum, millet or maize. However, the economically-enriched farmers buy feeds from the local agro dealers to supplement the feeding of poultry for growth and productivity as most of them keep improved indigenous poultry.

8 According to GoK 2013, of these BMUs, 61 are in Mbita, 33 in Suba, 30 in Rachuonyo North and four in Homa Bay.

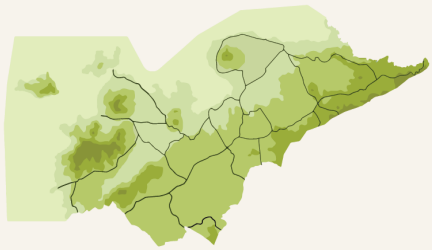
Past and future impacts of climate hazards in Homa Bay

Historical annual mean precipitation (mm/year)



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

Historical annual mean temperature (°C)

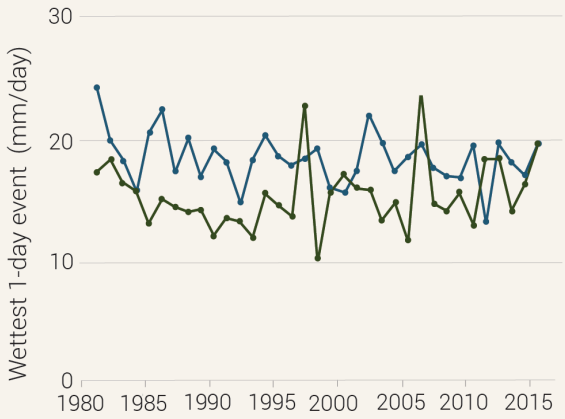


Data sourses
Temperature: WordClim (1970-2000)
Roads: Digital Chart of the World

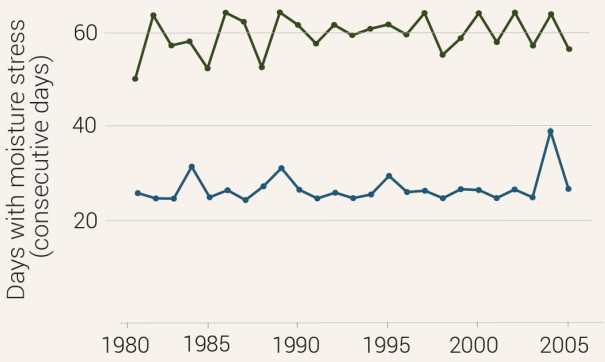
Flood hazards

Drought hazards

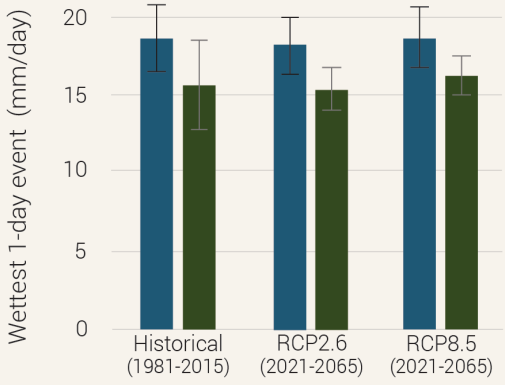
Historical extreme flood events



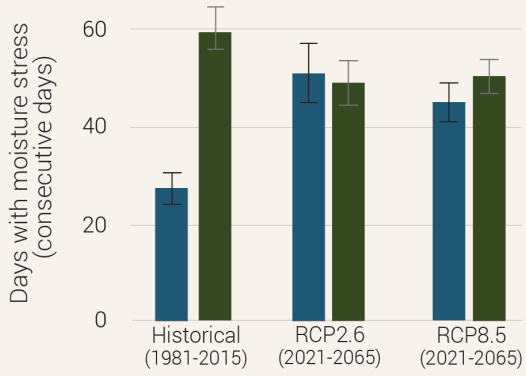
Historical drought stress events



Historical and expected extreme flood events



Historical and expected drought stress events



January - June July - December

Local poultry production is found across all AEZs in the County. Indigenous chickens are reared for both food security and income generation. The proceeds are used to pay school fees and for emergencies such as hospital bills etc.

Some farmers have built housing to protect the poultry from predators, diseases, pests and adverse climatic conditions. Because of the informal nature of production, information related to inputs and production volumes and quantities is limited. The faith-based organization Caritas of Homa Bay also constructs poultry units to support poor farmers in the County through their Agricultural Environmental Program. The Kenyan Department of Veterinary Services (KDVS) supplies vaccination services on demand. There is a revolving fund for vaccines such as Newcastle disease vaccine in this value chain, minimum cost is KES 100[9] for 50 birds. The Kenya Livestock Department (KLD) trains farmers in local poultry management however the farmer-staff ratio is very low and the County has only 2 veterinary doctors.

Homa Bay County Local Poultry Value Chain Cooperative Society (LPVCCS) is the main cooperative for poultry farmers in the County. However, it is not actively involved in the market dynamics of the value chain. Other actors involved include middlemen involved in promotion, selling and pricing.

Most of the decisions regarding local poultry is done by women who have a say in the disposal, sale and use of income accrued from the sale. Women are more likely to be owners of small livestock compared to men who prefer larger livestock such as the local cow, goat and sheep as they fetch more income than poultry keeping.

Agricultural sector challenges

Homa Bay County has the potential to feed itself and export surplus to neighbouring counties, however it faces perennial food shortages and food insecurity due to low productivity (GoK, 2013), driven by factors such as outbreak of pests/diseases, low soil fertility, inadequate staff at the ward level, high poverty levels, dependency on rain-fed agriculture and increased climate hazards (drought and floods). The situation is further exacerbated by low acreage under cultivation, which implies that harvested products remain far below household consumption needs in virtually all seasons.

Inadequate access to farm inputs such as improved genetic material for plants and animals, pest and vector control, and machinery contributes to poor quality and low volume of production. Due to the limited availability and prohibitive cost of high quality plant and livestock breeds and husbandry services, crop and livestock farmers have resorted to using low quality seeds and uncertified planting materials.

Unsustainable land management practices compromise agricultural productivity in the County. Farmers have limited skills and training due to low uptake of technology and the scarcity of adequate agricultural extension personnel. Farmers often use poor agronomic practices because of lack of knowledge that lead to environment degradation consequently limiting the exploitation of County's agricultural potential. The availability of adequate technology is important in production, processing, preservation and marketing of the agricultural products. For instance, in fishing, there are only two processing plants while fishing is a key economic activity in the County. The lack of appropriate technology and skills can be attributed to the remaining 36% of the population that are illiterate. Dependency on rain-fed agriculture also greatly affect productivity of rain-fed crops and livestock in the County where only 13.3% of the land is irrigated.

Low mechanization of production to increase efficiency and poor storage facilities have hampered progress in the sector as over 90% of farmers use traditional production and storage methods which limit their output. The main storage facilities in the County are cribs (75%) and gunny bags (24%). Only a paltry 1% of the population appears to use silos. Silos are used mostly by the National Cereals and Produce Board in their mini depot in Magunga (GoK, 2013).

The general lack of market information and skills amongst farmers and the business community has hampered the expansion of markets for products from the County. Weak and inadequate farmers' cooperative societies coupled with the poor road network in the County are major hindrances to the marketing process. Cooperatives such as Homa Bay County AMCS, Homa Bay CLPVCCS are not taking up their role adequately in the market dynamics. Poor organization of farmer groups has exposed farmers to exploitation by middlemen.

HIV/AIDS-related morbidity and mortality has diminished the workforce and reduced agricultural productivity in the County. The County has an HIV/AIDS prevalence of about 27.1% compared to the national average of about 6.3% (NACC, 2014).

9 Sh.2 per bird

Other factors which have hampered farming activities include rules of inheritance of land and subsequent land fragmentation. This has reduced land sizes among families leaving only small plots of land for food production.

Despite being major contributors to agricultural production, cultural norms deny women access to production resources and decision-making. Men still control the means of production. Women cannot access credit for significant investment requiring a title deed as collateral as land title deeds remain under control of men. Culturally, women are not empowered to make serious decisions unless it is in consultation with their spouses.

Major constraints to the growth of the fishery industry include: water hyacinth (which obstructs the fish landing sites), use of illegal fishing gears, inadequate patrols, receding water level, exploitation by middlemen and declining fish stocks due to overexploitation in the lake.

The major problems facing the livestock sector are Tsetse fly infestation, especially around Lambwe valley, drought, malnutrition, and low quality livestock breeds.

Climate change and agriculture risks and vulnerabilities

Climate change and variability: historic and future trends

There is some variation in precipitation throughout Homa Bay County, with the southern areas further from Lake Victoria receiving the most precipitation around 1750 mm, and the northern areas closer to Lake Victoria receiving 1000-1250 mm of precipitation per year. The temperature is fairly consistently warm through the year. Precipitation also consistent throughout the year, although the first wet season (January-June) receives a slightly greater amount. Intense precipitation and heat stress are both hazards that contribute to agricultural risk in the County throughout the year, whereas dry spells are more an issue in the second wet season.

Historic analysis of weather in Homa Bay 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 and consistently close to 60 consecutive days of moisture stress, whereas moisture stress is consistently less than 30 days during the first wet season. Extreme precipitation and flood risks[10] are moderate to low in both seasons, with most years receiving between 10 and 25 mm of precipitation on the wettest day[11].

Climate has already been observed to change slightly in the County. Since 1981, the first wet season—the predominant rains of the year—have experienced a moderate (1°C) increase in mean temperature and associated reduction in crop cycle, and a small (~10%) decrease in precipitation on average. The combination of increased temperatures and decreased precipitation make for an increase in drought risk. The second wet season experienced a mild (~0.5°C) increase in temperature, and a significant (20–30%) increase in precipitation. This has resulted in increased risk of flooding.

Looking to the future in the years of 2021-2065 (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 0.7% in the first wet season, and 3% in the second wet season. Prolonged moisture stress is projected to occur in the first season of the year, whereas intense precipitation looks to change little in either season. Consecutive days of moisture stress is projected to almost double in the first wet season from approximately 25 days to around 45-50. In contrast, moisture stress in the second wet season is projected to decrease from 60 consecutive days of moisture stress to approximately 50 days. These projections of future climate change under the two climate scenarios—RCP 2.6 and RCP 8.5[12]—show some small differences, but generally show the same future projections, suggesting climate change impacts will be fairly similar during this time frame irrespective of greenhouse gas emissions.

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

11 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.

12 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.

Climate from the farmers' perspective

Farmers in Homa Bay County attest to the on-going and intensifying changes to climate and weather patterns in the County over time. Increased cases of flooding have been reported around Magunga in Gwasi, Sindo areas, Wahambla in Homa Bay, lower parts of Ndhiwa, Lambwe area and Rusinga in Mbita, lower parts of Kochia. Unpredictable seasonal patterns affecting agricultural activities such as the onset and end date of the seasons have been observed: "a while back, it was so obvious that the long rains would start at 15th March but now it goes beyond mid-April and beyond". Uneven distribution of rain coupled with inaccurate weather forecasts lead to more crop failure. Cases of hailstorms have been recorded in Homa Bay Town, Homa Bay West ward, South Kanyabala and North Kanyabala, Arujo areas and in some parts of Ndhiwa bordering South Kanyabala. Increased temperatures as high as 38°C around January to February leading to the depletion of natural pastures on which 99% of livestock depend as well as loss of livestock. Around January and February, the communities experience water scarcity because the rivers dry up. Increased incidences of crop and livestock diseases in the County were also reported.

Water level in the lake is rising due to extreme rainfall and/or the deposition of sediment brought in by the rivers upstream.

Climate Vulnerabilities across Agriculture Value Chain

Climate change has already had adverse effects on agricultural production systems and food security as a result of increased frequency of extreme weather events and unpredictability of weather patterns. Excessive rains and subsequent flooding, shifting patterns of storms and droughts, and warmer overall temperatures are just some of the effects (FAO, 2013). In Homa Bay, where crops are rain fed and livestock farmers depend mostly on natural pasture, long dry spells and irregular rainfall exacerbate the problem of low yields and leave rural households even more susceptible to food insecurity. Climate hazards affect the key value chains in different ways, as discussed below.

Maize

Maize production in Homa Bay County is almost entirely dependent on rainfall, and thus highly susceptible to climate shocks. Moisture stress is a major limiting factor for maize growth and productivity, as is high rainfall/floods. Maize requires high rainfall of 1,200 to 2,500 mm, whereas the County's annual rainfall is low and unreliable ranging from 700 to 800 mm. The lakeshore lowlands areas (Mbita, Karachuonyo, Homa Bay, Suba) are more likely to be affected by the predicted reduction in rainfall that will affect soil moisture in the LM2, LM3, LM4 and LM5 agro ecological zones. Maize yields are therefore likely to be affected unless soil and water conservation measures, use of drought-tolerant varieties and irrigation are adopted. Maize is also vulnerable to weeds and pests that proliferate during moisture stress, requiring treatment with pesticides or chemicals that most of the farmers in the County cannot afford. This is attributed to the high absolute poverty rate that stands at 44.1%[13]. Maize production over the years according to farmers' testimonials has experienced increased weed and pests such as: parasitic striga weeds, stem borer and stalk borer, and large grain borer commonly known by farmers as osama. The increased incidences of weed infestation lead to competition for soil nutrients and lower production consequently leading to demand spikes and high prices for buyers

The reduction in soil moisture makes tilling the land difficult and leads to seeds scorching which causes poor germination. Maize is sensitive to acidity which exacerbates when there is moisture stress. Increased incidences of pests such as the large grain borer can cause considerable losses in stored maize and also lead to a higher demand of storage pesticides. The economically endowed can cope with price increases, however, poor farmers can't. This is further exacerbated by the poor storage facilities in the County. In spite of this, farmers are culturally attracted to maize and reluctant to shift to heat-resistant sorghum or millet. Lack of diversification makes them more vulnerable to climate risks. Farmer groups and insurance companies could cover smallholders' risks against adverse climatic conditions, however, there are no farmer cooperatives in this value chain.

13 This equals to 458,136 persons (GoK 2013).

Flooding, likewise, has adverse effects on maize production. The lower agro-ecological zones (LM2, LM3, LM4 and LM5) such as Karachuonyo, Gwasi, Mbita and Ndhiwa are more vulnerable to flood risks. Flooding leads to crop yield losses, soil erosion, water logging, and leaching of soil nutrients and fertilisers. The seeds viability is also reduced as the seeds rot in the soil.

Excessive rainfall especially during harvest can lead to increased rotting. In addition, inadequate drying of maize under wet conditions is likely to increase chances of aflatoxin contamination. Only 1% of the population appears to use silos for storage (GoK, 2013).

Damage to the road network due to flooding leads to increased prices of farm inputs. Flooding also causes transport problems to the 12 islands which are accessible only by boat increasing the cost of transportation and consequently production costs.

Bean

Heat stress is a limiting factor to the growth of beans and so is flooding. Beans require a moderate, well-distributed rainfall (900-1200 mm) per annum, however, dry weather during harvest is also very important. During the dry season, beans require up to 50 mm of water per week. Prolonged dry conditions are harmful to beans. Rainfall in Homa Bay County is low and unreliable, ranging from 700 to 800 mm. Lake shore lowlands (LM2, LM3, LM4 and LM5) such as Mbita, Karachuonyo, Homa Bay, Suba are more vulnerable to the heat stress compared to the uplands. Suitable soil type for beans range from light to moderately heavy with organic matter in the soil, however some parts of the County have black cotton soil which is very hard when dry and difficult to till.

Heat stress leads to poor quality, inadequate and high cost of seeds in the County. Beans experience scorching of the seed leading to low or no germination. Resource-poor farmers (especially women) are more vulnerable to this impact, as they are not able to buy the good quality seed when prices are high. Pests and diseases are also more pronounced during the heat stress, e.g. a higher incidence of aphids. This will exacerbate yield losses and at the same time require a higher usage of pesticides leading to increased production costs. The high temperatures also make the dusting chemicals ineffective.

Beans are also sensitive to flooding. Farmers in the lake shore low lands (LM2, LM3, LM4 and LM5) are more susceptible to flooding than the upland farmers. Beans require a moderate, well-distributed rainfall of 900-1200 mm per annum, however, rainfall in excess can be detrimental. Excessive rainfall leads to rotting of bean seeds and leaching of soil nutrients and fertilisers applied reducing the fertiliser efficiency. Incidences of pests and diseases are also more pronounced during floods, they include whiteflies, root rot, angular leaf spot. Farmers have little or inadequate knowledge on proper drainage and raised-bed cropping. However, the economically endowed farmers are able to use some of these techniques unlike the poor farmers.

Flooding choke plant roots interfering with the translocation of nutrients. Suitable soil types for the bean range from light to moderately heavy, with soil organic matter. However, most soils in the County are black cotton soils that, difficult to till when wet. Flooding also leads to poor quality of seeds due to moulding which lowers colour and quality, reducing the palatability and market price of the seeds. This will make the household that depend on the sale of beans for their livelihood more vulnerable than others.

Dusting, threshing and winnowing are all compromised. Dry weather during harvest is very important. However, the wealthier farmers have the capacity to buy tarpaulins, covered sheds, drying granary for post-harvest handling. This kind of equipment is not accessible to poor farmers in the County.

Excessive rain damages the road network in the County, affecting transport and leading to increased production costs.

Pest and disease incidences for bean are likely to increase with droughts and floods. This includes aphids during the dry periods, white flies during the wet season, as well as diseases such as root rot and angular leaf spot. These lead to increased production losses and higher use of pesticides.

Poultry (local)

Local poultry are adversely affected by heat stress due to inadequate feeds, water availability, and the increased incidence of disease leading to poultry deaths. This consequently leads to a decline in production and/or the loss of stock.

Again, the effects of heat stress are not experienced equally by all farmers; wealthier farmers will have the capacity to procure water or engage in water harvesting techniques and purchase and/or store supplementary feed as well as construct proper housing for the birds. Contrarily, the increased costs of production will adversely impact the poor and likely result in low volumes of trade, and increased prices. Farmers in the lowland lake shore areas are more likely to be affected than the upland farmers. Farmers with inadequate knowledge on the usage of vaccines are likely to be affected more than farmers who have the knowledge and access to vaccines.

In addition, high rainfall/floods damage storage facilities and road networks, threatening the availability and price of important inputs such as vaccines. As the market supply reduces, the price for local poultry increases.

Fish

Heat stress leads to increased evaporation and reduced water levels both at the fresh water lake and the fishponds. The nets become difficult to use when the water level is low. Low water levels compromises the survival of fingerlings. This also has an impact on the breeding sites, making harvesting difficult and in many cases forcing farmers to reduce grow out period from 9 to 6 months.

Heat stress increases the cost of preservation of fish and also leads to a shortage of fish in the market, creating the need for fish imports (such as the China fish).

Fish is also sensitive to high rainfall and flooding, causing migration out of the ponds. High rainfall may have adverse impacts on the power supply and communication network which is an important input for storage. Power cuts will affect the quality of the fish harvested and kept in cooler boxes and refrigerators. Damage to the road network will affect the transportation, processing and access to the market.

Adaptation to climate change and variability

On-farm adaptation practices

To cope with climate change and variability, farmers in Homa Bay County have come up with a number of on-farm adaptation strategies. Some of the most widely used on-farm strategies include: tree planting, improved soil and water conservation, adaptation of early-maturing varieties and water harvesting, post-harvest handling, value adding processing, among others. There is a lot of integration of indigenous knowledge in adaptation options such as the use of sawdust in the preservation of grains and the use of salting, smoking, drying of fish. The infographic below presents into more detail these adaptation options, along with potential strategies that could complement these, to increase farmers' resilience to climate hazards. Annex 5 identifies patterns of adaptation options by head of household, as well as the common input requirements and challenges to implementation.

Soil and water conservation strategies are most common in the warm and dry AEZs (LM2, LM3, LM4 and LM5) and they include conservation agriculture (cover cropping, minimum tillage, and crop rotation techniques), planting of Napier grass, mulching. Such practices are mostly adopted by youth- and male-headed households (28%), given that soil conservation is usually more labour-intensive. There is a need for more awareness raising about the benefits of such practices among farmers in order to scale out adoption.

Water harvesting techniques used in Homa Bay County involve the construction of water pans, shallow wells, and water tanks. Such strategies are, however, less adopted by farmers[14], given the large fresh water surface area of the County (1,227 km^2), as the county borders Lake Victoria to the west. Additionally, such strategies tend to be capital-intensive, limiting adoption by resource-poor farmers.

14 Adoption rates are highest among youth- and men-headed households, compared to female-headed households: 24.8%, 34.0% and 13.2% respectively.

Tree planting and agroforestry initiatives are facilitated by the National Environmental Management Authority (NEMA), the Kenya Forestry Service (KFS), and Caritas Homa Bay, who actively support the County's efforts to increase its forest cover. However, community participation in such initiatives is still low and is related to limited awareness raising among the County population.

Farmers also opt for change in crop, livestock and fish types and varieties/breeds to respond to climate shocks such as increased temperatures, drought and floods. Farmers in the warm and dry zones have taken up early-maturing varieties (of maize [DH 04 and Simba], cassava [MM series, Minjera] and beans, among others) and varieties resistant to drought (groundnut, millet, green gram, and sorghum). In aquaculture, farmers shorten the fish-rearing period from 9 to 6 months. However, in general, adoption of such strategies are hampered by farmers´ poor access to improved seeds, given high prices (especially of the early-maturing varieties and improved local breeds of livestock and artificial insemination).

Most of the farmers in the County depend on natural fodder. However, due to the climatic shocks in the County, some of the farmers shift to feed conservation and diversification. The push-pull technology that discussed in the next section, promoted by the International Centre of Insect Physiology and Ecology (ICIPE) has had significant benefits for dairy farming, since silverleaf desmodium (*Desmodium uncinatum*) and Napier grass are both high quality animal fodder plants. Farmers in the warm and dry AEZs (LM2, LM3, LM4, and LM5) tend to practice this more as they are adversely affected by climate shocks.

Value addition increases the shelf life of the products and competitive advantage on the markets, yet it is not widely practised by farmers in Homa Bay County. Some of the few value addition activities include grading, dehulling and flour-making (for cereals and pulses), oil extraction (for oil crops such as sunflower, common in AEZs UM3, LM2 and LM3), drying and extraction (for medicinal plants), grading and chopping (in the case of fodder crops). Fish farmers and fishermen engage in salting, smoking, drying activities. In general, there is little knowledge on value addition techniques among farmers.

Off-farm adaptation practices

Off-farm services, such as early-warning systems, extension, capacity building and training, post-harvest handling and storage facilities and market information, are offered to farmers to increase their adaptive capacity. Such services are offered by a variety of actors, from local government (such as the meteorological, veterinary, agriculture, and livestock departments) to faith-based organizations such as Caritas of Homa Bay, to international organizations such as the International Centre of Insect Physiology and Ecology (ICIPE) and the United States Agency for International Development (USAID).

Many of the off-farm services are organized through participatory scenario planning meetings facilitated by the ASDSP. These meetings are organized every season and bring together key stakeholders under the guidance of professional experts who assist in collectively finding ways to interpret the information (both local and scientific knowledge) into a form that is locally relevant and useful. They plan for worse, normal and good scenarios in every season based on seasonal forecasts given by the meteorological department. This information is then disseminated to different stakeholders through participatory advisory bulletins. These bulletins include advisories on the weather forecasts, highlights, expected hazards, type of seed varieties that will best suit a particular agro ecological zone, and the best breeds that are most adaptable to the expected hazards, adaptation strategies, such as conservation agriculture, tree planting etc. They also disseminate it through the radio as the majority of farmers can afford radio and listen to broadcasts of vernacular radio stations such as ramogi and sunset.

Early-warning systems enable farmers to know when and where to plant and when to move with the livestock in the event of climate hazards. The Kenya Meteorological Department (KMD) is responsible for the County's early-warning systems. By integrating scientific and traditional knowledge, KMD generates seasonal forecasts and disseminates the information to relevant stakeholders through Chief barazaas and WhatsApp to the heads of the departments.

Agricultural extension officers are used to sensitize and train farmers on sustainable land management

practices such as intercropping, conservation agriculture, water harvesting, composting, and agro ecological crop selection by considering crops that have a comparative advantage in a particular area. Extension agents play a key role in supporting the adoption of improved farming practices and adaptive coping techniques through practical on-farm demonstrations.

The Kenya Department of Agriculture (KDA) organizes demonstration plots of crops that have comparative advantage in the agro ecological area, for instance, sunflower in Mbita and Suba Sub Counties, maize in the upper parts of the County such as Karachuonyo. These demonstration farms are located within the 40 wards of the County vary in sizes from 0.25 acres (banana), 0.5 acres (pineapple) and 1 acre (maize, sorghum, sunflower). In these model farms, the KDA is providing inputs and capacity building to farmers. However, the challenge is the high farmer-to-staff ratio, which is at 1 to 1600 farmers.

Caritas Homa Bay is involved in capacity building of farmers to enable local-lead research. Other non-governmental organizations such as ICIPE are also involved in extension services and farmer field days, farmer field schools (FFS) and farmer teachers. The KLD also provides extension services and training and disseminates livestock technologies.

The Adaptation to Climate Change insurance program and the Weather-Based Index insurance introduced in the County ended in 2014. The uptake by farmers was poor. Some farmers felt that the services offered by insurance companies were unfavourable. For instance, fish farmers preferred that the engine of the boat should be insured in the waters and not on-shore. As the risk of the former is higher than the latter, the insurance companies were not willing to insure thus few farmers bought the premiums.

The various cooperatives that focus on production and marketing for different value chains often assume responsibility for providing market information for their members, as well as linking farmers to direct buyers or markets. Such cooperatives include AMCS, LPVCCS, Rangwe Dairy Cooperative Society (RDCS) and Homa Bay County Peanut Value Chain Cooperative Society (PVCCS). The cooperatives and farmer groups such as Ogongo Development Group are engaged in promotion, pricing and linking farmers to the buyers. However, the information regarding markets and marketing channels is weak and not uniformly distributed across the County.

The main storage facilities in the County are cribs (75%) and gunny bags (24%). Silos are used mostly by the NCPB in their mini depot in Magunga. The rudimentary method of food storage has led to several cases of aflatoxin contamination (GoK, 2013). Caritas of Homa Bay is actively involved in post-harvest handling techniques such as the use of sawdust and solar dryers. A small percentage of the farmers use metal silos. The County government is also involved in the provision of cooler boxes to the BMU along the riparian areas for safe storage of fish produce before it is sold.

The capacity to deliver relevant and timely information to farmers throughout the County is constrained by coordination, infrastructure, and resource constraints and must be managed through collaborative efforts with the key stakeholders.

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

Poultry (local)

	Provision of inputs	On-Farm production	Harvesting storage and processing	Product marketing
Extreme rainfall/floods	Destroy local feed sources and resources; damage poultry housing; increased disease incidences	Reduced feed quantity; increases cost of production; delayed vaccination and reduced effectiveness	Reduced yields; impeded transport of products to the market; high perishability of products	Low farmer sale prices (farm gate); increased market prices (brokers/traders)
Magnitude of impact	Major	Major	Moderate	Major
Farmers' current strategies to cope with the risks	Building raised housing units; waterproof poultry housing; building farmers' capacity in handling vaccines	Supply birds and collect vaccines when the rains/floods subside	Set up poultry holding structures in the markets; storage facilities and vaccines, educate the farmers in the village in handling vaccines	
Other potential options to increase farmers' adaptive capacity	Construct water harvesting structures; implement soil conservation structures and drainage; construct vaccines storage centres and poultry resource centres	Construct of selling yards and slaughter houses; use of footbath at poultry houses; strengthen extension services	Establish raised storing structures; construct modern flood prevention structures	Form farmer groups for collecting marketing; use available marketing channels (electronic, social media, posters)
High Temperatures	Reduced poultry feed supply; increased disease prevalence; increased water demand	Heat stress; reduced growth rate; increase rate of water intake; increased cost of production; reduced effectiveness of vaccines	Reduced production; increased energy requirements (cold storage and refrigeration)	Increase price of birds; loss of market and marketing opportunities; low sales
Magnitude of impact	Moderate-Major	Moderate-Major		Minor-Major
Farmers' current strategies to cope with the risks	Use locally available feeds resources e.g. sunflower cakes	Establishment of water harvesting techniques	Use of cooler boxes; transport poultry products and vaccines during morning hours and in ventilated crates or in flasks that contain ice	Sale to chicken brokers/merchants
Other potential options to increase farmers' adaptive capacity	Establish farm feed formulation units; set up vaccine collection centres (Sub-County level); invest in water harvesting and storage facilities	Build farmers capacity handling and use of vaccines; plant woodlots to supply local construction materials	Construct shaded spaces within poultry houses; use of cold/ventilated storage an transportation facilities (meat and eggs)	Form local poultry cooperatives to market birds; use available marketing channels (electronic, social media, posters)

Bean

	Provision of seeds and other inputs	On-Farm production	Harvesting storage and processing	Product marketing
Floods	Poor access roads hamper the transportation of inputs (seed, fertilisers), high seed spoilage (rot, pregermination); increase pest and disease incidences	Water logging; increased pests and diseases incidence; leaching of the nutrients; poor seed germination; rotting of seeds; stunted growth; poor nutrient absorption; reduced herbicides efficiency	Poor yields hence low volumes for package and store; challenges in produce storage (spoilage due to high moisture) delayed transportation of produce	Poor access roads hamper the availability of produce; low market supply (scarcity); low farmer sale prices (low quality)
Magnitude of impact	Major-Severe	Moderate-Severe	Moderate-Major	Major
Farmers' current strategies to cope with the risks	Construction of drainage channels; delayed application of fertilisers	Timely farm activities to coincide with dry weather for harvest; use of farmyard manure which releases nutrients slowly	Use of draught animals for produce transportation; use of tarpaulin to spread and drying produce; sorting of produce	sale of seed locally and at farm gate; family consumes the lower quality produce
Other potential options to increase farmers' adaptive capacity	Use appropriate technologies to drain off excess water (cut off drains, terraces); use of weather forecast to guide on timely planting and inputs purchase; use of aboveground input storage structures	Conservation agriculture; proper timing and placement of fertilisers (stay at root zone); use of composted manure (enhance soil structure and function of inorganic fertilisers); planting on ridges	Implementing of granaries and appropriate storage bags; use grain drying sheds; use of ash for pest control; improvement of feeder roads and asphalt roads	Introduce grain banking for balancing produce availability in the markets; access to crop insurance products (cushion against loss)
Increase temperatures/ Drought	Reduced seed viability; reduced input access and increased cost (low supply)	Heat stress; poor seed germination, stunted growth; flower abortion and poor seed production; accelerated plant development and reduction on grain filling period	Reduced yields; increased incidence of storage pests/rodents; poor produce quality and low quantity	High prices due to low or insufficient commodity supply volumes; reduced farmer prices (low quality); reduced market/marketing opportunities
Magnitude of impact	Major-Severe	Moderate-Severe	Major	Major
Farmers' current strategies to cope with the risks		Use of farm yard manure/compost; conservation agriculture	Applying dust under the shade early in the morning and late in the evening	
Other potential options to increase farmers' adaptive capacity	Use drought tolerant bean varieties	Upscale conservation agriculture practices (crop rotation, cover crops, minimum soil disturbance); Early Warning Systems; low cost irrigation structures; agroforestry	Access to improved storage structures (pest free structures)	

Maize

	Provision of seeds and other inputs	On-Farm production	Harvesting storage and processing	Product marketing
Floods	Limited access to inputs; increased incidence of weeds and diseases; destruction of infrastructure	Water logging; leaching of the nutrients; poor germination and establishment; increased cost of production; agronomic practices hampered by wet soils (planting, weeding etc.)	Reduced yields; reduced grain quality; insufficient drying, rotting and aflatoxin infestation from damp stores	Poor pricing of grain
Magnitude of impact	Moderate-Severe	Major-Severe	Major-Severe	Severe
Farmers' current strategies to cope with the risks	Renovation of feeder roads to connect farms and main road networks	Raising of planting beds (ridge planting); use of farmyard manure (organic fertiliser); minimum tillage-use of herbicides; hand picking of weeds	Improve cereal drying, shelling and storage infrastructure (cereal stores, silos); promotion of cereal banking and postharvest cereal management; capacity building on quality management	Establishment of commodity producer's groups and cooperatives
Other potential options to increase farmers' adaptive capacity	Set up drainage and water harvesting structures; introduce small farm mechanisation	Timely planting; promotion of extension services focusing on integrated pests, diseases and weeds management	Construct post harvest handling infrastructure e.g. cereal driers, cereal store; build capacity in post harvest handling shelling machines; Modify and improve road infrastructure	Form cooperatives for collective marketing; modify financial policies and create revolving fund for input supplies; policy and financial support to fabricate small machinery e.g. hand shelling machines
Increase temperatures/ Drought	Prevalence of pests incidences	Moisture stress; poor germination, seed scorching at emergence; poor pollination; reduction in grain filling; delayed planting and other crop husbandry practices; shift in cropping calendar	Reduced plant populations and therefore yields; reduced quality for milling; reduced grain shelf life; increased costs of storage pesticides	Low farm-gate prices; increased maize prices as the market supply is low
Magnitude of impact	Moderate-severe	Severe-Minor	Minor	Minor
Farmers' current strategies to cope with the risks	Introduce irrigation methods; attend training sessions from extension services; construction of feeder roads by the county government	Cover cropping, use of herbicides; capacity building on efficient use of pesticides	Capacity building on post harvest handling; construction of grain stores by the county government	Formed commodity producer groups; provision of subsidised seeds, and fertiliser
Other potential options to increase farmers' adaptive capacity	Increase adoption of water harvesting and irrigation structures; provide extension service to support water management	Crop rotation, minimum tillage; integrated nutrient and water management practices; weather forecast services to guide on timely planting dates; use of drought-tolerant varieties	Promote postharvest handling innovations; cereals banking; maintain in proper conditions roads and milling infrastructure; incentives for local manufacture of low cost storage facilities (metal silos)	Provide financial and policy incentives to strengthen existing cooperatives and commodity producer groups

Fish

	Provision of inputs	On-Farm production	Harvesting storage and processing	Product marketing
Floods	Variable water flows; blockage of water ways by debris and garbage; destruction of infrastructure	Loss of fingerlings and spawning grounds; damage of fishing nets	Storage and cooling facilities destruction; delayed transportation of produce	Low fish market supply due to oversupply and poor infrastructure
Magnitude of impact	Severe	Severe	Major-Severe	Major-Severe
Farmers' current strategies to cope with the risks	Reinforce water conservation infrastructure e.g. dykes	Protection of water catchment areas (reforestation); treatment of wasted water	Use of ice cool box for storage and, refrigerators; preservation through salting, drying, deep frying, smoking and cutting	Formed fish marketing groups
Other potential options to increase farmers' adaptive capacity	Protection of water catchment areas (reforestation); use soil conservation technologies; training farmers on dyke's construction	Build capacity in pond construction and good pond siting	Renovate and upgrade existing cooling and storage facilities; upgrade the road infrastructure	Improve access to foreign markets; high quality species; explore incentives to improve storage facilities
Heat stress	Reduced levels of water bodies	Interfere with spawning sites; depletion of fingerlings stocks	Reduced fish population and pond yields; harvesting premature fish; high rates of spoilage while reaching the market	Less fish stock to promote in the market; increased market price
Magnitude of impact	Major	Major	Major	Major
Farmers' current strategies to cope with the risks	Use of alternative water sources (Drilling); rainwater drains and channelling; conservation of spawning grounds e.g. wetlands and water catchment areas	Proper siting of ponds	Implementation of cooling facilities (cooler boxes, insulated refrigerated trucks); produce preservation (salting, smoking, drying) and value addition (frying and gutting)	Supply of electricity and road infrastructure
Other potential options to increase farmers' adaptive capacity	Build capacity on water harvesting techniques; introduce high quality species	Train farmers on proper pond siting and management; provide Early Warning Systems to guide decision in water management	Install appropriate storage facilities e.g. solar powered refrigerators	Improved access to foreign market, good storage facilities; improved credit facilities support investments; alternative energies for storage and transporting

Policies and Programmes

Policies are key considerations for agriculture decision-making, since they affect actions and outcomes related to resource use. Several programs aimed at broadly addressing the topics related to climate vulnerabilities have been put in place through the collaboration of local, national, international, governmental, nongovernmental, private and faith-based organizations and the community at large.

The Environmental Management and Coordination Act (EMCA) of 1999 was amended in 2015, including climate change considerations on the agenda. It guides ministries to consider climate change mitigation measures in their actions and budgets, requesting the establishment of environmental departments or designated officers in each County.

The Climate Change Act, 2016 provides a framework for funding operation and mitigation of climate change issues both at the national and at the county level. The National government has held several stakeholder meetings with the county government to domesticate the act.

The Forest Act of 2005 contains several innovative solutions to rehabilitate degraded sites and support the planting of trees nationwide. There is a strong emphasis on partnerships, the engagement of local communities, and promotion of private investment. KFS Homabay cooperates with the farmers groups and communities to implement activities related to forestry, climate change, forest conservation and environment. The Forest Act acknowledges forest community associations as important partners in forest management. The challenge with regards to the implementation and adoption is the lack of community participation.

The Kenya Veterinary Policy provides for an enabling environment for safeguarding animal life, health and welfare as well as animal propagation and production for food security and economic development. Homa Bay County aims to implement this policy to boost contribution of the animal component to food security and ensure that animal products (consumed or marketed) meet the highest safety and nutritional standards. Through the KLD, the County engages in inspection of the slaughtered livestock so as to ensure that diseases, disease- causing and disease-carrying agents are not transmitted between animals and humans.

Fisheries Management and Development Act, 2016 provides for the conservation, management and development of the fisheries and other aquatic resources to enhance the livelihood of communities that depend on the fishing.

Homa Bay County has a number of climate risk management programs which are spearheaded by various institutions. One such example is the Agricultural Environmental Program implemented by Caritas Homa Bay, which comprises two components. The Integrated Food Security initiatives aims at integrating food security approaches with health (especially HIV/AIDS considering that the County has a high incidence of HIV/AIDS of 27.1% [GoK, 2013]) in three Sub Counties: Rangwe, Ndhiwa and Homa Bay. The initiative engages farmers in a farmers´ research network and use a participatory approach to help farmers with agricultural research. Farmers also receive training on post-harvest handling techniques, such as the use of the sawdustvvv and solar dryers. Caritas also provides seeds to resource-poor farmers and was involved in the testing of 12 varieties of sorghum to identify adaptable varieties. Caritas also offers local improved male goats to the communities to improve breeds and dairy production – goat milk is believed to have important nutrients for the HIV/AIDS patients – and facilitates the construction of poultry units for farmers.

As part of the Climate Change component of the program, farmers receive training on conservation agriculture techniques such as minimum/zero tillage, crop rotation and permanent cover using dolly corns, pigeon peas, groundnuts. Caritas engages in tree planting campaigns and holds demonstrations in schools and churches, along introducing farmers to drought-tolerant crops such as cassava, sorghum and early-maturing varieties of beans. In close collaboration with other stakeholders such as GIZ, MoALF and Sustainable East Africa (SEA), they provide seed relief.

The dissemination of push-pull technology by ICIPE developed in collaboration with other partners addresses the five key constraints of cereal–livestock mixed production systems in Africa – insect pests (stem borers), the parasitic striga weed (as well as other weeds), poor soil fertility, soil moisture management, while also fulfilling the need for high quality animal feed. The push-pull technology involves intercropping cereals with a pest-repellent plant, such as desmodium, which drives away stem borers from the target food crop. An attractant trap plant, for instance Napier grass (*Pennisetum purpureum*), is planted around the border of this intercrop, with the purpose of attracting and trapping the pests. As a result, the food crop is left protected from the pests. In addition, desmodium stimulates suicidal germination of Striga and inhibits its growth. Push-pull also has significant benefits for dairy farming, since silverleaf desmodium and Napier grass are both high quality animal fodder plants. Additionally, desmodium is an efficient nitrogen-fixing legume that improves soil fertility. Moreover, because both plants are perennial, push–pull conserves soil moisture and continually improves soil health.

The ASDSP is a programme funded by the Government of Kenya and the Swedish government whose objective is to transform Kenya's agriculture into an innovative, commercial-oriented modern industry and alleviate poverty and improve food security. The role of ASDSP in Homa Bay County includes facilitation and coordination of participatory scenario planning with key stakeholders and dissemination through vernacular radio stations (Ramogi, Sunset) and barazaas, churches, as well as value addition development, where the key value chains include indigenous poultry, fish and sorghum.

The Accelerated Dairy Value Chain Project aims to transform the livestock in the County through vaccination against ECF and the synchronized artificial insemination. The County provides the first 4000 straws for free. So far, 2,000 straws have been administered. The approach is demand driven and at the moment the key beneficiaries are RDCS,Homabay,Kasipul and Kabondo Kasipul. This project is an initiative by the county Government of Homabay and ILRI.

Governance, institutional resources, and capacity

Like programs and policies, institutions are key to agriculture decision-making, since they shape actions and outcomes related to resource use. In agriculture, institutions' roles can be related to the design of policies and investment frameworks (government's), knowledge development and sharing (research institutes, universities), technological development (research institutes, farmer associations) or the delivery of financial and non-financial incentives for agricultural investments (credit institutions, trust funds) (FAO, 2010). In Homa Bay, there is a wide range of institutions, ranging from governmental to non-governmental to the faith-based organizations and the private sector, that are actively involved in climate-related issues. Some of the most prominent institutions are discussed below.

The KMD generates seasonal forecasts through data analysis and workshops held with key stakeholders, integrating scientific and traditional knowledge. Through participatory scenario planning the experts develop an information dissemination plan that may include sharing through the ASDSP environmental resilient officers, and radio.

The Kenya Forest Service (KFS) is a semi-autonomous government parastatal. KFS Homa Bay cooperates with farmer groups and the community to implement activities related to climate change, forestry, farm and dry land forestry, forest conservation and environment. The role of the KFS is to rehabilitate degraded sites and planting of trees. The percentage of the land under forest cover in the County is only 2.6% compared to the national forest cover of 6.9%. This is far from constitutional requirement. KFS joined the initiative to rehabilitate three hills: Asego hills, Samenya hills and Unga hills (project sponsored by the World Bank and implemented by Lake Victoria Environmental Management Program [LVEMP]). KFS works with various community groups and farmer groups in carrying out their mandate.

The activities of self-help groups is also important in the County. Abba Self-help group works in Kochia, advising farmers on the importance of trees. In Okundi Valley they have collaborated with local communities to rehabilitate the valley. Other self-help groups include but are not limited to: Ngegu BMU, KK self-help group, Werigu women group (actively involved in afforestation), Star of the Lake, and the Nyamauru Bamako Initiative. All these groups were funded by the LVEMP Phase 2.

KFS has partnered with the Biotechnology Department in Karura for about 70,000 hybrid seedlings that are adaptive and suitable for Homa Bay County. They sell the hybrids to the community at KES 20 per seedling. KFS has also collaborated with the Lake Basin Development Authority (LBDA) in the rehabilitation of Rangwe hill, where more than 5,000 seedlings were planted. However, there is resistance by the community in the adoption of tree planting as it is not self-driven. A lot of persuasion is needed to plant the trees, curtailing KFS´ key objective of KFS to increase the forest cover in the County. Lack of adequate resources and human capacity is also a major concern in carrying out these interventions.

NEMA is the N.I.E of the adaptation to climate change funds. The authority has been working with the world vision to implement climate change resilience program in Lambwe on the natural regeneration capacity. It has coordinated with FES to create awareness , It educates farmers on the importance of tree planting through their County Environmental Action Plans (CEAP). NEMA is also promoting green growth concept through green points which promote sustainable use of resources including innovations in the agricultural sector. It also trains the farmers on disaster preparedness and is part of the management committee at the County Government. However, lack of adequate human resources and funding curtails its operations. Likewise with KFS, there is resistance from communities with regards to tree planting.

The ICIPE Thomas Odhiambo Campus (ITOC), located in Mbita Point, was established in 1977, as a base for the Centre's research in the region. ITOC provides infrastructure for basic and applied laboratory and field-based biological and sociological research, as well as facilities for the development, testing and dissemination of environmentally-

safe and sustainable pest- and vector-management technologies in various agro-ecological zones. Research activities at ITOC cover four themes: human, animal, plant and environmental health. In particular, ITOC is the base of ICIPE´s push-pull technology.

Currently, the main dissemination pathways are farmer field days, farmer field schools (FFS), farmer teachers, print materials, extension personnel, and to a lesser extent, mass media.

The Forest Social Initiative (FSI) specializes in dryland species for charcoal production and. It is based in Magunga, where FSI promotes acacia species, as these are suitable species for this very dry area. However, community participation in this initiative is weak. World vision has worked with different stakeholders in Homabay county in initiatives such as planting trees to manage the climate change risks in Homabay. However, the institution is financially constrained in implementing its mandate considering that the needs of the county are way to many.

With the support of cooperatives, farmers can pool production from their individual farms in order to better meet market demand, reduce risk, access better financing acquire and share farm machinery and other assets, negotiate better prices, and jointly market their produce. Cooperatives in the County vary in size and influence. Some of the cooperatives in the agricultural activities include AMCS, LPVCCS, RDCS, and PVCS. The cooperatives and the farmer groups such as Ogongo Development Group are engaged in promotion, pricing and linking farmers to the buyers. However, the cooperatives and farmer groups are not well structured and not well coordinated, limiting their activities.

Private sector actors are also key actors. Agro-veterinary companies engage in the distribution and sale of agro-chemicals and other farm inputs and often train farmers on the safe utilization of pesticides, fertilisers and other input supplies. Financial institutions such as banks provide loans to farmers. These are not specifically agricultural loans, but general loans that farmers use to purchase production and storage inputs. The extent to which such formal financial institutions are accessible and used by farmers is not clear.

Synthesis and Outlook

Climate risks have detrimental impacts on the lives of the population of Homa Bay County, including famine experienced in the lowland AEZs (LM2, LM3, LM4 and LM 5), losses of crops and livestock and depletion of fish stock.

Farmers traditionally use their indigenous knowledge to adapt to climate change. Some of the most widely used on-farm strategies include: tree planting, improved soil and water conservation, adaptation of early-maturing varieties and water harvesting, post-harvest handling, value adding processing, among others. However, integration with scientific knowledge can be improved to ensure effective adaptation to changing climate conditions.

The majority of farmers rely on rain-fed agriculture which is unreliable in Homa Bay County in particular in the warm and dry low AEZs (LM2, LM3, LM4 and LM5). Opportunities include water harvesting for crop and livestock production, development of irrigation schemes to increase yields during the dry seasons through smallholder irrigation schemes and through Public-Private Partnership & collaboration. Water harvesting and promotion of efficient water-use technologies (drip irrigation, green house), and conservation agriculture is key for these AEZs. There is also a need for promotion and production of drought-tolerant crops such as millet, sorghum, green gram to cope with the recurrent climate shock experienced in these zones.

Expensive farm inputs limit agricultural productivity in the County, as most of the farmers are not in a position to afford the expensive inputs. This is further exacerbated by climate risks resulting in scarcity, high demand and consequently higher prices of inputs. Farmers in the lower AEZs (LM2, LM3, LM4 and LM5) are more vulnerable to adverse climatic conditions. Organization of farmers into groups/ cooperatives would facilitate access to inputs, credit, and markets and would increase the likelihood of better process.

Homa Bay County has a high prevalence of HIV/AIDS (27.1%) leading to high morbidity. There is a strong correlation between health and productivity. Thus, there is an urgent need to tackle the high incidence of the HIV/AIDS that is particularly affecting the fish value chain. This can be achieved through mass campaigns where the key stakeholders need to be involved.

Farmers in Homa Bay County experience post-harvest losses due to rudimentary storage methods. Over 90% of farmers use traditional production and storage methods which limit their output. Only a minority (1%) uses silos. There is a need to adopt adequate storage facilities and technologies such as hermetic bags, community grain and input storage facilities, alongside the promotion of agro processing. This effort needs to be the result of collaboration of various stakeholders, including research institutions, financial institutions, relevant County department, community and individual farmers. Such efforts wound lead to reduced post-harvest losses and increase the value of the produce and the trading prices on the market.

Regarding distribution and marketing, inadequate and insufficient markets and outlets where farmers can sell their produce, coupled with limited processing or value adding opportunities can be counteracted with the development of farmer groups, market infrastructure and processing plants that can help meet the demand and increase the value of products. In order for this to occur, access to timely, accurate information (especially market-related) is crucial for farmers and the business community. Climate change Act, 2016 provides a framework for promoting climate resilience. There is the need to downscale this to the county level so as to manage the climate change risks.

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

Annex 1: Income generation from major food crops in Homa Bay County.
Annex 2: Quantity and value of livestock products in Homa Bay County
Annex 3: Main sources of income from agriculture disaggregated by gender
Annex 4: Yields of maize and beans in Homa Bay County by gender and season.
Annex 5: Main adaptation options identified in Homa Bay County

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