

Climate Risk Profile Garissa County

Highlights

- Garissa is a hot and dry county where extensive pastoral livestock production dominates. In addition, some agro-pastoral farming, both rainfed and irrigated, can be found along the River Tana. These forms of agriculture are the main sources of livelihood in Garissa, contributing about 87% of the household incomes and employing more than 88% of the active population. However, more than 40% of the county's population suffers food poverty, relying yearly on food aid, given unproductive lands and the climate impacts on agriculture and livelihoods.
- Drought, floods, and high temperatures already challenge productivity, incomes, and food security in the county and are expected to pose even bigger challenges in the future. Production challenges such as resource competition, invasive species, and low input use, as well as social factors such as poor infrastructure, insecurity, low literacy and high poverty levels compound the effects of climate change and further complicate farmers' ability to cope with them.
- Crop farmers' coping strategies for droughts and floods include the use of early-maturing plant varieties, water harvesting, staggered cropping, and post-harvest storage and processing. However, the lack of resources, infrastructure, and technical skills often results in low uptake and adoption of these strategies.
- Livestock farmers, especially cattle farmers, have resorted to diversifying their livelihood strategies to include crop farming and charcoal burning among other activities. They also employ a number of livestock-specific coping strategies, including construction of irrigation and water storage facilities, livestock migration, feed conservation, vaccination campaigns, destocking and change of livestock species. Producers also engage in value-adding practices such as boiling and fermenting milk and salting and drying meat. On the other hand, pastoralists who lose their animal stocks (usually as a result of drought) are forced to drop out of the pastoral system and take on farming activities as an alternative livelihood source.
- Off-farm services that are available and that increase crop farmers' and livestock keepers' climate adaptive capacity include extension services, storage facilities, and climate information provision such as Participatory Scenario Planning. Financial services such as insurance schemes for livestock / crop and credit facilities are very limited.
- Several government, non-governmental, community-based, and private organizations support climate change adaptation efforts in the county through alternative channels, such as extension services, input delivery, and policy-making. Local beneficiaries are generally engaged in the planning phases of interventions, yet they are often absent from subsequent implementation, monitoring and evaluation phases.
- In this sense, successful implementation of climate adaptation strategies will require strengthening the institutional and financial capacity of key actors. In turn, farmers must have the information to understand, and the tools to respond to climate change and risks such as onset of drought and floods. Appropriate adaptation and mitigation response will be contingent upon farmers' ability to access crucial extension services in a systematic way.
- Only about 1% of the land has been issued with title deeds, the most common land ownership regime being communal. This has limited long-term individual investments. Moreover, inadequate demarcation of land under conservation, grazing land, animal migration corridors and crop land has resulted in historical conflicts over natural resources. Landscape planning through stronger local institutions, conflict resolution mechanisms and collective planning processes are important in reducing conflicts and increasing implementation of climate adaptation strategies by pastoralist communities.
- Agriculture provides the largest primary occupation (40%) for men, youth and women (25%, 9% and 6% respectively). The adult female and youth are among the most vulnerable populations in the county, with lowest adoption rates of adaptation strategies. This indicates a need to target interventions that incentivize adaptation strategies among these groups.

List of acronyms

ADESO	African Development Solutions
ASDSP	Agricultural Sector Development Support Programme
ASAL	Arid Semi-Arid Land
ATC	Agricultural Training Centre
AEZ	Agro-ecological Zone
CIAT	International Center for Tropical Agriculture
FAO	Food and Agriculture Organization
GEF	Global Environmental Facility
KACCAL	Kenya Adaptation to Climate Change in Arid and Semi-Arid Lands
KALRO	Kenya Agricultural and Livestock Research Organization
KAPP	Kenya Agricultural Productivity Programme
KDLDP	Kenya Dryland Development Programme
KFS	Kenya Forestry Service
KLIP	Kenya Livestock Insurance Programme
KMD	Kenya Meteorological Department
KRC	Kenya Red Cross
KWS	Kenya Wildlife Service
LPD	Livestock Production Department
MD	Meteorological Department
MoLAI	Ministry of Lands, Agriculture and Irrigation
MoALF	Ministry of Agriculture, Livestock, and Fisheries
NCCRS	National Climate Change Response Strategy
NCCRS	National Climate Change Response Strategy
NCPB	National Cereals and Produce Board
NDMA	National Drought Management Authority
NEMA	National Environmental Management Authority
SCCF	Special Climate Change Fund
UNDP	United Nations Development Programme
VCC	Value Chain Commodity
WB	World Bank °
WFP	World Food Programme



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 Garissa County, where climatic events in the recent past hit the agriculture sector significantly. In 2008, it was reported that the River Tana changed course, endangering thousands of livelihoods, in terms of water scarcity along the areas in its original course, and floods in the areas along the new course¹ In May 2015, more than 160,000 households in Garissa were faced with starvation following prolonged drought. The area had not received rainfall in two years. Hence pastoralists moved far in search of water and pasture for their livestock as animals died because of the drought (The Star 2015). Again towards the end of year 2015, severe flooding occurred in areas along River Tana. The river overflow caused displacement of more than 1,000 families².

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

1 As reported by Irinnews (2008).

2 As reported by Floodlist News (2015).

Agricultural context

Economic relevance of farming

Garissa County is located in the Northeastern region bordering Somalia to the East, Lamu County to the South, Tana River County to the West, Isiolo County to the North West, and Wajir County to the North. The county covers an area of 44,175 km² most of which is flat and low lying, rising from an altitude of 20 to 400 m. The county is classified as Arid Semi-Arid Land (ASAL) and lies within Agro-Ecological Zones (AEZ) IV-VI, with an average annual rainfall of 250 - 350 mm. There are two rain seasons: the Short Rains season from October to December and the Long Rains season from March to May. Rainfall is typified by short torrential downpours. Temperatures are relatively high and range between 28 and 38°C. Soils range from the sandstone, dark clays in some patches, to alluvial soils along the seasonal rivers (Laghas), the river Tana Basin and the Lorian Swamp. The soils have low water retention capacity and are highly erodible (GoK, 2013).

Agriculture is the main economic activity in the county and livestock rearing through nomadic pastoralism is the dominant livelihood system. The main livestock breeds are cattle (Boran), goats (Galla), sheep (black-headed Persian) and camel (Dromedary, one-humped). The main livestock products are meat, milk, hides and skins. There is also small-scale fishing along the river Tana. The county received about KES 2.4 billion from the major livestock and livestock products, with milk and beef contributing about KES 1.83 and 0.29 billion respectively (see Annex 1).

Crop farming is practiced through rainfed and irrigated systems. Rainfed farming occurs in riverbeds, floodplains, and depressions where seasonal rivers (laghas) discharge run-off water. The total area for rainfed farming is 649,000 ha, of which 11,445 ha are dedicated to crop farming of mostly cereals (maize and sorghum) and pulses (cowpeas and green gram). Maize is the main crop, accounting for the largest share of crop income in the county. It generated about KES 50 million in 2013 (see Annex 2). The total land area with irrigation potential is 32,000 ha, of which only 3,446 ha is currently under irrigation. The major crops grown are high-value horticultural crops, including fruits such as mangoes, pawpaws, bananas, melons and citrus.

The major vegetables grown are tomatoes, onions, capsicum, kales, chilies and spinach (GoK, 2013).

Agriculture contributes significantly to the county's Gross Domestic Product (GDP) and provides about 87% of the average household income. In the pastoral areas, livestock production contributes about 80% of the household income. Crop farming is the main economic activity for the agro-pastoralists where it contributes up to 50% of household income. Moreover, employment in agriculture is the highest among all sectors, accounting for 88% of the employed population (GoK, 2013). The majority of those employed in the sector are producers. For pastoralists, the men and boys look after the migrating animals, mostly cattle and camels; women and girls manage sheep and goats that are kept closer to the homestead. For the agro-pastoralists, the women are in charge of most of the crop farming.

People and livelihoods

The population of Garissa was about 699,534 in 2012, 46% of which were women and 54% men. The youth population, aged between 15 and 30 years, constitutes roughly 28% of the county's population. By 2017, the population is expected to reach 849,457, growing at a rate of 3.96% compared to the national growth rate of 2.9%, as per the 2009 population census. The relatively high county-level population growth rate is associated with low child mortality rates and strong religious and cultural beliefs which advocate non-adherence to family planning. The county is sparsely populated with 16% living in urban areas like Garissa town. The population living under absolute poverty (below US \$ 1.9 per day) is estimated to be 50% of the total county population. Urban and rural poverty reaches rates of 55% and 64% respectively. The prevalence of wasting (weight for height) is 9% while stunting (height for age) is 39% (GoK, 2013).

Water scarcity already affects the entire county with only 27,725 of the households (28% of total households in the county) directly connected to water sources. The main water source in the county is River Tana and various seasonal rivers (laghas). These are

also the main sources of water for irrigation. Water use is distributed among livestock (53%), domestic (30%), irrigation (10%) and other uses (7%). Energy for cooking is from primary materials; most of the population in the county depend on firewood (79%) and charcoal (18%). Women and girls fetch firewood from surrounding bushes while charcoal is mostly sourced from burning the *Prosopis juliflora* (commonly called Mathenge). This is permitted, since Mathenge is an invasive plant. Only 12% of the population uses electricity for lighting, and this is mostly concentrated in urban areas (GoK, 2013).

The literacy rate of the population aged 15 years and above is 40%, with more literate men than women. The net completion rate for primary education is 63% while the rate for those proceeding to secondary school is about 58% (transition rate). Their nomadic lifestyle explains the low enrolment and transition rates. Early marriages among girls also contribute to the low transition rates. At secondary school level, enrolment and completion rates are 3.5 and 77% respectively. Tertiary education has been growing in the past years, with establishment of public and private university campuses, colleges, and youth polytechnic institutions in Garissa town and other urban areas. Few academic institutions are found in rural areas (GoK, 2013).

The main source of livelihood in Garissa County is livestock rearing for milk and meat through nomadic pastoralism. The main livestock bred are cattle, goats, sheep, and camels³. Rainfed and irrigated crop farming is also common.

The potential for rainfed agriculture (maize, sorghum, cowpeas and green grams) is 649,000 ha (14% of the county's total land), of which only 1.8% (11,445 ha) is currently cultivated. Irrigated crop farming systems, mostly high value horticultural crops such as tomatoes, onions, capsicum, kales, chillies, and spinach, and major fruits such as mangoes, paw paws, bananas, melons and citrus are found within a strip of 1-2 km along the River Tana. The irrigation potential in the county is 32,000 ha, of which almost 11% (3,466 ha) is irrigated using water extracted from the river through canals and suction pumps. In addition, artisanal fishing is also common along the river (GoK, 2013).

Agricultural activities

Garissa County has a total of 894,000 ha of arable land. This represents 20% of the total land area in the county and about 3% of the national arable land. Land in Garissa County is largely communal, as the population is predominantly pastoralists who live on shared land. However, some farming activities are carried out on privately owned land, with an average farm size of about 1.3 ha along the River Tana. However, only 1% of the farmers have title deeds (GoK, 2013).

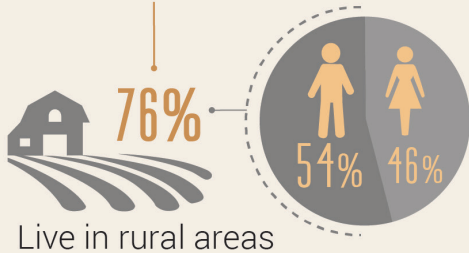
According to GoK (2014), adoption of new technologies is low in the County; it is lower in female-headed households compared to male-headed households. For instance, Artificial Insemination is used by only 0.5% of male-headed households. The main inputs used include seeds, herbicides, and fertiliser or manure; these are used by less than 20% of the households. Veterinary drugs, vaccines, and acaricides are the main inputs used in livestock production. However not all households use them. For instance, de-wormers are used by 54% of households, vaccines by 49%, and acaricides by 35%. The main factors constraining the use of inputs are the high costs and inaccessibility of input markets. Fertiliser use is relatively low. Organic manure is used by 9.2% of the farmers and fertiliser by 4.3% at planting. Fertiliser is applied as a top dressing by 0.5% of the farmers. The use of improved planting materials such as improved seeds stands at 15.7%, while herbicide use is at 11.4%. The constraints for input use range from high prices to distance to input market and lack of inputs when they are needed. At the household level, male-headed households use more inputs than female-headed households, both for crop and livestock production (GoK, 2014). However, although the adoption of inputs is already low, the perception on environmental consequences is that less fertilisers and chemicals should be used to protect the environment.

3 In 2014, Garissa County had 1,104,375 heads of cattle; sheep 1,089,870; goats 1,947,310; and camel 375,490 (GoK, 2015)

Livelihoods and agriculture in Garissa

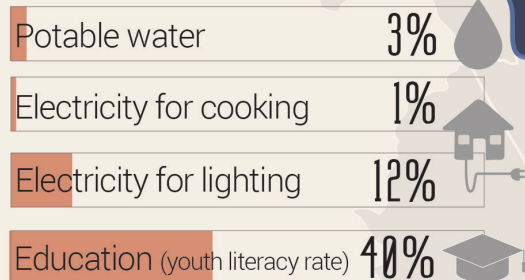
Demographics

1.5% Of Kenya's population
699,534 inhabitants



Access to basic needs

50% of the population lives in **absolute poverty**



Food security

44% of the population suffers from **food poverty**

ND of household **income** spent on food

ND People **undernourished**
39% Children **stunted**
9% 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)

County's farming area

894,000 ha 20%

43% of the population employed in agriculture production

1% of farmers have title deeds ND% are women

Farming activities

Food crops



0.1%

Cash crops



0.2%

Livestock



Cattle (heads) 1,104,375
Sheep (heads) 1,089,870
Goat (heads) 1,947,310
Camel (heads) 375,490

Of county's agricultural land

Water uses



Fertiliser types (% of households)



9% Organic manure
4% Basal fertiliser
1% Top dress fertiliser

Pesticide types (% of households)



1% Field pesticides
ND Storage Pesticides
11% Herbicide

Agricultural value chain commodities

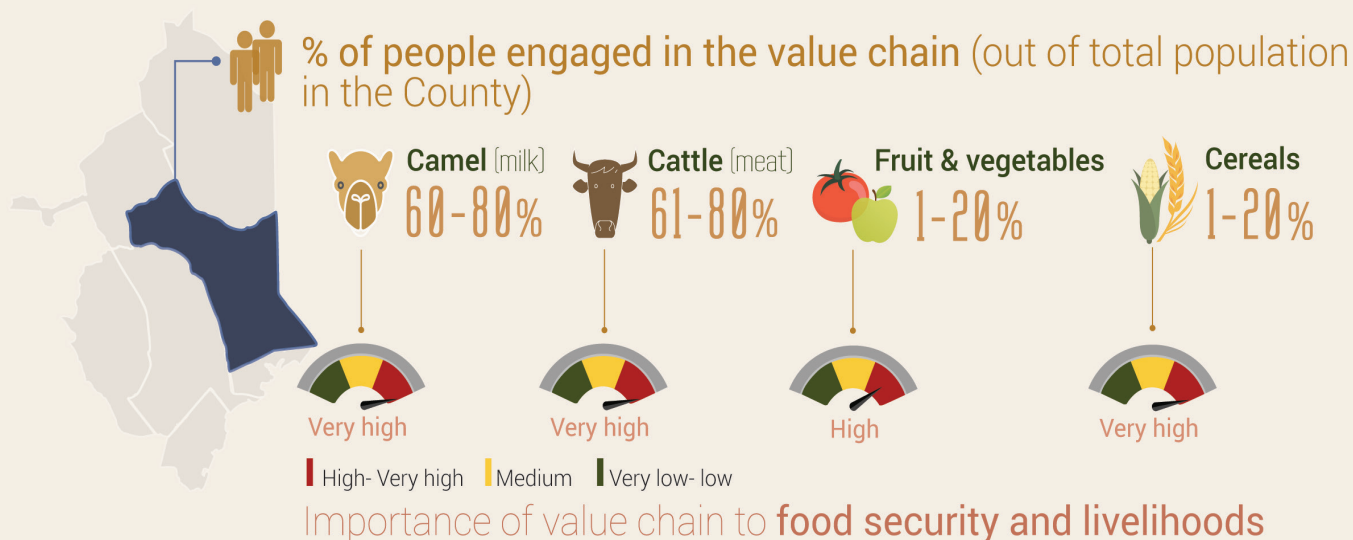
With nomadic pastoralism and agro-pastoralism being the major agricultural activities in the county, the main value chain commodities (VCCs) also fall within these two systems. The value chains have been prioritized for development interventions by different government organizations and programmes, such 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 Programme (KAPP). For the development of this County Climate Risk Profile, four major value chain commodities (VCCs) were selected for in-depth analysis, based on their contribution to food security, productivity characteristics, and importance to the economy. These VCCs, 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 (US\$/bag), dietary energy consumption (Kcal/ capita/ day), protein content (g of protein/ 100 g of product), iron content (mg of iron / 100 g of product), zinc content (mg of zinc / 100 g of product), and Vitamin A content (IU Vitamin A / 100 g of product). These VCC are: meat (cattle, goats, sheep), milk (cattle, goats, sheep, camels), cereals (Maize), and Fruits and vegetables (See Annex 2).

Meat

Meat is a key livelihood product especially for the pastoralists. About 70% of the population are engaged in the value chain, almost entirely in the production nodes, as there are few processors in the county. The production system is mostly nomadic pastoralism which is practised countywide and at an extensive level⁴ Agro-pastoralism is also practised; however, it is spatially confined to along the riverine of Tana River. This is where the pastoralists have engaged in crop production. Thus there is a shift to sedentary life as migration is limited.

The main animals reared for meat are cattle, goats, and sheep. The men are mostly involved in cattle and camel herding while women are involved in goat and sheep rearing. Cattle and goats are also migrated to other counties and even into neighbouring Somalia, especially in times of drought. Women normally remain behind to take care of the homestead, including children and the elderly. In addition, men are denominated the main decision-makers with respect to issues of production and marketing of meat. The livestock are generally sold to butchers and the Kenya Meat Commission (KMC). In 2014, the beef, chevon, mutton and camel meat produced amounted to 2,565,244, 1,083,880, 141,232, and 4,903,300 kg respectively (GoK, 2015).

Agricultural value chain commodities in Garissa



⁴ Extensive production denotes the practice of allowing animals to graze freely.⁵

Camel (milk)

In Garissa, milk is an important livestock product, as it is used directly as food as well as preserved and consumed during times of scarcity. Moreover, milk is commonly sold to earn household income. Over 80% of the households depend on milk directly or indirectly. Milk is mainly obtained from camel. However, cattle (local and cross-breeds), goats (local and exotic) and sheep (local) also produce milk. In 2012, Garissa produced 61.3 million litres of milk valued at KES 1.8 billion⁵ (GoK, 2013). As with meat, the responsibility for making decisions on the value chains is largely divided between the genders but milk marketing considerations are dominated by women, even in male-headed households. Since the animals that produce meat are usually the same ones that produce milk, they are reared in the same way and in the same geographic space. Milk is sold to traders (brokers) who later sell to individual consumers.

Cereals

Cereals grown in the county include maize, sorghum, and rice. Maize is the dominant crop in terms of the numbers of farmers engaged in its production; however, less than 20% of the population is involved in the maize value chain. Maize is an important commodity to local household food security. It is produced at small scale level (average of 1 acre) both in the hinterland and in the riverine areas. According to focus group participants, this is a result of relief food dependency, competition from high value crops such as tomatoes, wildlife menace, and competition for space with livestock. On-farm activities such as land preparation are executed by the farmers themselves and sometimes receive advice from county government or NGOs. The farmers sometimes use hired labour in the fields; the labour is sourced from outside the county, including in Kitui County. Agro-input shops, NGOs, and county government distribute inputs, which include seeds and fertilisers. Extension services are offered by the county government, NGOs, and private service providers.

Fruits and vegetables

Fruits and vegetables are mainly grown along the riverine areas of Tana River. About 10% of the county population is engaged in horticulture. Farms are small, averaging 1.3 ha, and use small-scale irrigation. Key

crops include annual crops, mainly tomatoes and watermelon, and perennial crops, mainly bananas, guava, mangoes, oranges, and pawpaw. Men are typically the main decision makers on issues regarding crops, except for tomatoes (GoK, 2014). This suggests that whereas the other crops are cultivated as cash crops, tomatoes also serve as a food crop.

The fruits and vegetable value chain is mainly composed of farmers who produce, sell, and add value, as well as brokers who serve as the major buyers. Sales of produce are carried out individually and/or through cooperatives. Value addition by the farmers is largely driven by transportation (a youth-dominated activity) and bulking at collection centres; processing is minimal. This has resulted in farmers selling their produce to the brokers at very low prices since they lack bargaining power.

5 Cattle, goat and camel

Agricultural sector challenges

The county's agricultural sector faces a number of challenges. A poor road network makes a large proportion of the expansive county inaccessible, especially during the rainy season. The road network comprises 1,479 km of earth surface roads, 304 km of gravel and 21.5 km of bitumen roads (GoK, 2013). There are three bridges on the River Tana, at Garissa, Bura, and Masalani. Due to the poor road network, agricultural products cannot reach the market in good condition; spoilage is common especially for perishable products such as fruits, vegetables, and milk.

Processing, marketing and storage facilities are not developed. Due to inadequate energy and power sources, processing of plant and animal products is a challenge, leading to high losses of perishables products like tomatoes and milk. Lack of appropriate technology and skills to process and preserve agricultural and dairy products limits the expansion of markets for these products. About 90% of the farmers use traditional, less efficient methods for storing agricultural produce. The farmers' cooperatives and societies are not active enough to share technologies on improved practices. With the extremely high poverty rate (50% absolute poverty), adoption of technologies is low as farmers lack the resources to purchase proper inputs such as fertilisers, certified seeds, pesticides and herbicides. At the same time, the market is constrained by the weak purchasing power of consumers. This situation, coupled with poor road networks, leads to a complicated and underdeveloped market for agricultural products in Garissa.

Insecurity as a result of inter-clan conflict over resources such as land, water, and pastures, coupled with terror-related insecurity is a concern in most parts of the county. Incidences of insecurity have increased since the Kenya Defence forces entered Somalia in 2011 to root out the Al-Shabaab militants. This has affected agricultural production since long-term investment is not feasible and imported labour becomes scarce. Only 1% of the population hold title deeds while most of the land is communally owned. Unless the people are supported by strong local institutions, this constraint will continue to limit the farmers' capacity to develop their land. Consequently, poor land use practices such as overgrazing and deforestation will remain common, leading to environmental degradation.

Climate change is already manifested in the county

through: unpredictable and reduced rainfall; frequent and prolonged drought; and unpredictable floods. The effects range from low productivity due to poor body condition in livestock to total crop failure due to heat stress and waterlogging. The impact of climate change on agriculture is further compounded by illegal encroachment and settlements, logging, and overgrazing. Settlements along the livestock migration corridors to watering points obstruct the animals' access to water. Logging and overgrazing increase soil erosion, leading to low agricultural production.

Finally, inadequacy of sharia-compliant credit sources limits investment in agriculture due to religious attitudes to interest-attracting loans. Access to insurance services including livestock insurance is limited as pastoral farming is considered very risky due to frequent droughts. Thus when there is prolonged drought or disease outbreak with consequent loss of animals, the farmers are left in a very poor state as restocking is difficult.

Climate change and agriculture risks and vulnerabilities

Climate change and variability: historic and future trends

Garissa County has a relatively hot and dry climate throughout the year. The average temperature is greater than 27°C throughout the majority of the county. There is a strong south to north gradient of decreasing precipitation some southern parts of the county receiving greater than 1000 mm of precipitation per year, the central part of the county receiving around 500 mm, and the north/western parts of the country consistently receiving less than 250-500 mm. A small pocket of the north western part of the county receives less than 250 mm precipitation per year. As such, heat stress, dry spells, and drought are hazards that strongly contribute to agricultural risk in the county, especially in the more northern parts of the county. The Tana River runs along south-western boarder of the county where flooding along riparian areas is also a risk, especially due to periods of rain upstream in the Tana River.

The most extreme weather conditions tend to occur during July-December (second wet season)⁶. Historic records of temperature and precipitation in Garissa County indicate increasing variability in heavy precipitations in the second season (particularly in November), compared to the first season (particularly April) since the 1981. Extreme precipitation 20 mm or greater in a day⁷ occurred in five years since 1981 during the second wet season. In contrast, January-June (first wet Season) experienced only one year with a single day receiving over 20 mm of precipitation. This intense precipitation within Garissa River County can directly contribute to flooding, especially along smaller rivers and streams, it should be noted that extreme precipitation events in upstream parts of the Tana River outside of the county are more important in causing flooding along the main stem riparian areas of the Tana River (e.g. Muranga County). Moisture stress and dry spells also occur more prominently during the second wet season (approx. 93 days of consecutive moisture stress), being about 20 days longer than in the first we season (approximately 65 consecutive days with moisture stress). However, there has been

an increasing trend in moisture stress in the first wet season since 1981, which has not occurred during the second wet season.

Climate has already been observed to change slightly in the county. Since 1981, the first wet season has experienced a high (1.5°C) increase in mean temperature and associated reduction in crop cycle, and a fairly strong tendency for decreasing precipitation on average (on the order of 25% reduction). The combination of increased temperatures and decreased precipitation make for an increase in drought risk. The second wet season experienced a very mild (~0.2°C) increase in temperature, and no change in precipitation.

Looking to the future in the years of 2021-2065, both extreme precipitation and prolonged moisture stress are projected to occur, but the changes are different during different seasons. Within 30 years (by the early 2040's) temperature is projected to increase by 1.0°C, with the first wet season projected to experience even greater changes. And by this time, precipitation is projected to increase by 9% in the first wet season, and 22% in the second wet season. Increased extreme precipitation is projected to occur during the second season, with the highest single day of precipitation increasing on the order of 25%. The first wet season is projected to experience no change or even a slight decrease in the single day greatest precipitation. The changes are the opposite for future drought stress. The first wet season is projected to experience 15-20 additional consecutive days with moisture stress, whereas the second wet season is projected to experience a decrease of approximately 15 days. Whereas, historically the second wet season experienced 25 days longer of consecutive moisture stress, in the future this is projected to be the opposite with the first wet season experiencing longer periods of consecutive dry periods than the first. These projections of future climate change under the two climate scenarios⁸ —RCP 2.6 and RCP 8.5— show some difference, with the climate change patterns described above being slightly greater with higher greenhouse gas concentrations.

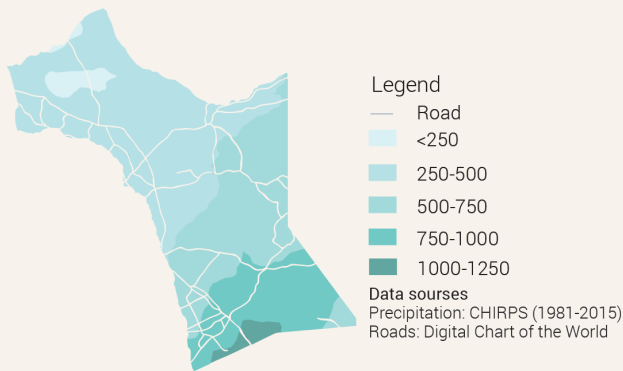
6 For this study, the First Season (Season 1) refers to the 100-day wettest period during the months of January to June, while the Second Season (Season 2) is the 100-day wettest period during the months of July-December.

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

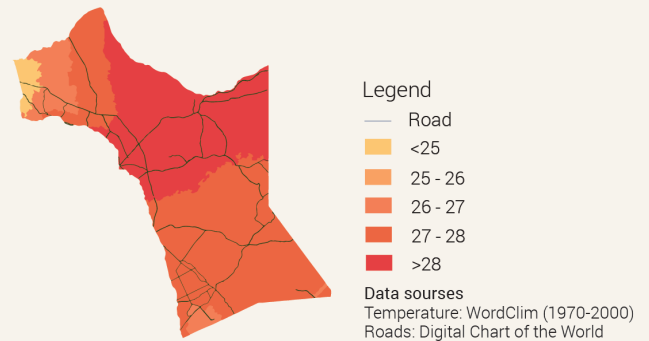
8 The two RCPs, RCP2.6 and RCP8.5, are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6 and +8.5 W/m2, respectively). The pathways are used for climate modelling and research. They describe two possible climate futures, considered possible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

Past and future impacts of climate hazards in Garissa

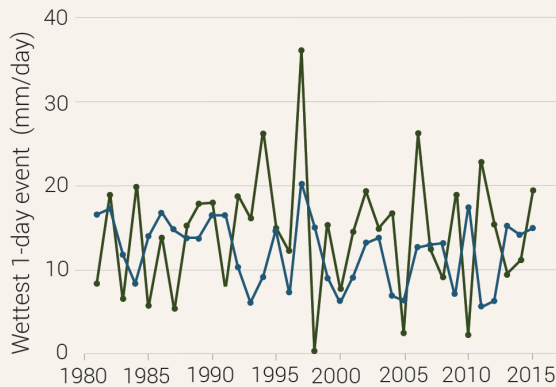
Historical annual mean precipitation
(mm/year)



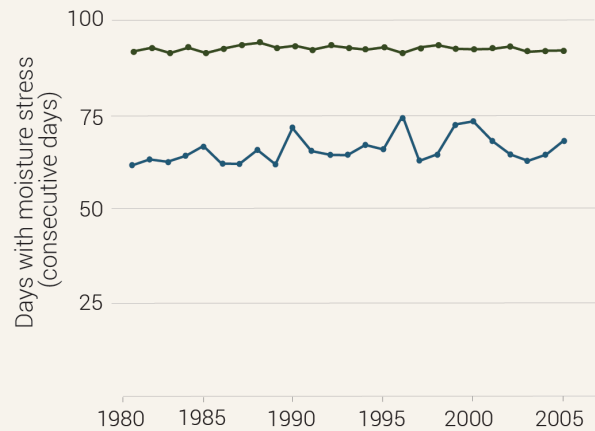
Historical annual mean temperature
(°C)



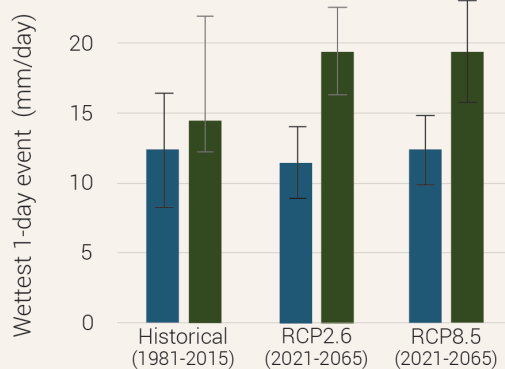
Historical extreme flood events



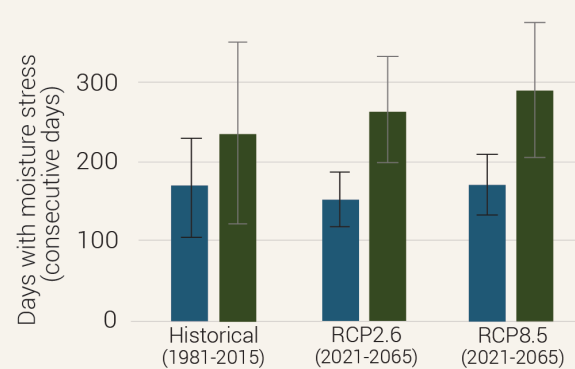
Historical drought stress events



Historical and expected extreme flood events



Historical and expected drought stress events



■ January - June ■ July - December

Climate from the farmers' perspective

Using focus groups, we asked farmers to reflect on the changing climatic conditions that they observe and if, and how, they affect their livelihoods. The most common changes cited include warmer temperatures, frequent floods, and prolonged drought periods. Livestock production was perceived to be the most vulnerable farming activity, due to the increasing difficulty of finding water sources and the increased incidence of pests and diseases. Major climate change and variability hazards noted by farmers include prolonged drought periods where the water holding infrastructure (e.g. water pans) becomes totally depleted and high temperatures generate heat stress that destroys crops. With reference to precipitation, farmers noted that in May 2016, they were unprepared for the floods caused by heavy rains in the catchment areas of River Tana. The alerts had come late hence the farmers had little time to act. Alternating droughts and floods have caused River Tana to change course as happened in 2008. As a result, crop farmers have at times ended up being located far from the water sources that they depend on.

According to farmers, the consequences of these climate hazards range from moderate inconveniences to extreme and irreparable damage that threatens their livelihoods. Pastoralists and agro-pastoralists lose livestock during times of extreme drought due to a combination of diminishing pastures and waning water sources, at a time when rising temperatures increase animals' water requirements. Changing patterns of grazing land and water reserves require migration and lead to the related effect of environmental destruction that results when people resort to unsustainable practices such as charcoal burning as alternative livelihoods. Burning Mathenge to make charcoal is common; it is allowed to use this tree species to make charcoal. Other trees are protected.

The changes described above often place enormous pressure on existing resources and generate conflicts over ownership of, and access to, water and pastures. These conflicts take the form of human-human conflicts between crop farmers and pastoralists, and human-wildlife conflicts. An example of the latter type of conflict occurs when snakes move near homesteads in search of water. At the same time, medicinal plants, including those considered important for soil fertility, are rapidly disappearing with the changing climatic conditions. Meanwhile, better-adapted invasive plants, including *Proposis juliflora* (Mathenge) are proliferating at an increasing rate. In the process, they complicate agricultural activities by overtaking grazing pasture

and making land clearing more difficult. Mathenge was introduced in the area to reduce land degradation. However, it colonizes an area easily, choking off pasture. But it has economic benefits as it is a source of firewood. Pods are consumed by livestock and it is the only plant without limitations for charcoal burning. The plant is dispersed by animals hence it is found in almost the entire county.

Climate vulnerabilities across agriculture value chain commodities

Across the county, climate change and variability pose serious threats to the value chains identified in this work. The following section highlights the major climate risks faced by key value chains.

Cattle (meat)

Major climatic risks and hazards faced by this value chain are precipitation dependent, namely, drought and floods. The consequences of these hazards vary in intensity along the value chain. At production level, meat is more sensitive to drought than to floods.

The consequences of drought at the production level include reduced pasture and water, resulting in low productivity and compromised immunity and body condition. The cost of vaccines and drugs tends to increase during drought periods, as the incidence of disease outbreaks leads to higher demand. Prolonged drought leads to starvation and deaths of animals and related loss of livelihoods over time. At the post-harvest or processing level, lack of water forces processors to use poor hygiene practices. This can lead to contamination and human infection. Water scarcity also increases the cost of processing, since water has to be brought in from afar. At the marketing level, the quantity and quality of meat decreases with drought. This greatly affects prices, with repercussions to transporters and the off-farm, processing workforce. On the other hand, floods often contribute to soil erosion and reduced pastures, poor communication due to damaged transport system to markets, disease outbreaks, increased prevalence of internal and external parasites, forced displacement, and death of animals.

When drought or floods strike, the impacts are felt in most cases by the entire family. This is so since livestock has a significant importance of providing food and income.

Camel (milk)

Major climate hazards affecting milk include droughts, high temperatures, and flash floods. Droughts and extreme heat are experienced county-wide, while flash floods occur mostly along the riverine (Garissa, Balambala, Fafi and Ijara) and Ewaso area (Gurufa). Milk is more sensitive to drought and ambient temperatures than to floods both at production and value addition (transportation⁹) levels.

Drought leads to reduced pasture and water for the animals hence milk production is reduced as the body condition of the animals deteriorates. At the same time there is increased occurrence of diseases such as Rift Valley Fever, and pests, including ticks. High ambient temperatures result in milk spoilage as there is no effective refrigeration¹⁰ available to the farmers. Low milk production affects the food security of farmers, and especially pastoralists. Moreover, although there are few processors, they also receive less milk when production decreases as a result of drought and increased ambient temperatures. Transporters are also affected by the decreased demand for transportation. Floods experienced in Garissa are mostly flash floods¹¹ The consequences of the floods range from destruction of fodder crops and pasture, especially along the riverine; washing-out of infrastructure, especially roads; and increase in livestock diseases and animal deaths. As a result, milk output is affected, and what milk is produced is often spoilt before reaching the market.

Cereals

Maize is seriously affected by both floods and droughts along the entire value chain. Prolonged and frequent droughts lead to crop failure. For the farmers located outside the county's irrigation schemes, the production that survives drought still stands the risk of being destroyed by the pastoralists' livestock and wildlife. In addition, due to high temperatures and scarcity of water, the maize is of poor quality and more susceptible to storage pests. Farmers lack the ability to purchase inputs such as fertilisers and improved seeds. The cycle of low productivity and food insecurity therefore continues, especially for subsistence crop farmers.

Flooding along the River Tana leads to destruction of crops, roads and even storage facilities. This makes access to production inputs such as seeds, fertilisers and extension services difficult. The floods result in poor seed germination and wastage of fertilisers due to leaching. Cases of aflatoxins were reported to be more common during flood seasons, severely affecting marketing of maize.

The underlying factors of these hazards include: inadequate technologies for water harvesting; improper grazing management and a lack of watering corridors (Malkas); wildlife invasion; priority given to other crops, especially high value crops; over-dependence on relief food; ignorance of climatic information like Early Warning Systems (EWS); lack of proper storage facilities; undeveloped market; and high poverty and illiteracy levels among the population, which reduce their capacity to use climate information in day-to-day farm decision-making.

Fruits and vegetables

Both droughts and floods greatly affect the fruits and vegetables value chain. The impacts of floods are especially severe. Drought affects the whole county while floods are common along riverine areas of Tana River that cover Garissa, Balambala, Fafi and Ijara. The consequences of drought include: increased incidences of pests and diseases; increased use of pesticides; increased cost of irrigation and labour; increased farmer-wildlife conflicts; increased crop farmer-pastoralist conflicts; low crop production; increased salinity and high rates of produce spoilage. Consequences of floods include: destruction of crops and irrigation infrastructures; delay in planting and application of inputs such as fertilisers; increased cost of relocation of farm machinery; increased soil erosion and degradation; inaccessibility to farms; leaching of nutrients; pests and diseases washed from upstream; proliferation of *Proposis juliflora* (Mathenge); riverbank erosion; river change of course and poor quality of produce.

High temperatures in February/ March negatively affect production, especially in the case of tomato. During this time, flower abortion and pests incidences

⁹ Transportation is considered a value adding activity, as milk fetches higher prices when transported to the market

¹⁰ Cooling of milk is usually done using local equipment, often simply a can wrapped with cloth.

¹¹ Sudden rush of water over a sloping surface usually destructive, caused by heavy rainfall. However, in Garissa the heavy rainfall in the catchment areas of Tana River is the cause of floods in the County.

are high. The cool months of June-July positively enhance production of the commodity, leading to overproduction particularly in the months of August/September. Overproduction, coupled with limited value addition and inadequate marketing organization results in serious postharvest losses.

Although some farmers adopt strategies to cope with the climatic hazards such as planting in time and using early-maturing varieties, the low literacy and high poverty levels remain a challenge. These factors impair adoption of new technologies and inputs, such as the use of improved varieties, fertilisers, and pesticides. Some of the underlying factors that contribute to the destructive impact of these hazards include: inadequate irrigation technologies and over-reliance on the riverine areas; conflicts with wildlife; lack of proper storage facilities; over-dependence on food aid; and undeveloped markets. High poverty and illiteracy levels among the population reduce their capacity to adopt measures that reduce climate change-related risks for example by building water dams or using climatic information like EWS.

Adaptation to climate change and variability

Farmers in Garissa County have adopted various strategies to cope with the variations and changes in climate conditions that affect agricultural production and food security. Results from the ASDSP survey of 2013 showed that nearly half of all farmers, regardless of gender, age, or agricultural designation (pastoral, agro-pastoral, or crop producers) have adopted soil and water conservation strategies including water harvesting, soil conservation, irrigation, and tree planting. Male-headed households are more likely to apply climate change adaptation strategies that require greater inputs and target productivity such as water harvesting and conservation. Women are more likely to adopt strategies aimed at diversifying production, and post-harvest value-added activities such as food storage facilities and tree planting. Some adaptations are specific to certain value chains whereas others cut across the value chains (see Annex 3).

On-farm adaptation options

In recent years, some nomadic pastoralists have adopted agro-pastoral practices by diversifying into crop farming, including the cultivation of fodder to help maintain the body condition of livestock during

prolonged periods of heat and drought. Cultivation of additional food crops has helped to protect farmers from shocks that result in loss of stock by providing an alternative source of income and nourishment. These crops include fruits and vegetables such as tomatoes. However, conversion to agro-pastoralism has been limited and has mostly occurred along Tana River within a strip of 1-2 km from the river.

In lieu of additional crop cultivation, some pastoralists have adopted practices aimed at fortifying their stocks against climate change and shocks. Farmers, both independently and through private and public technology-sharing programmes, have identified indigenous and non-native livestock breeds that are more resilient to climate-related shocks, particularly drought. These include the local breeds and cross breeds. Other farmers (about 5% of all households) have begun to diversify or change animal type such as cattle to camel as camels are more drought resistant than cattle.

For both livestock and crop producers, water harvesting is the most widely used means of facing climate change and shock. Nearly half (47%) of all households in Garissa use water harvesting inputs such as water pans, dams, or tanks to ensure productivity and sustainability. Farmers express great interest in water conservation practices and the rate of adoption might even have been higher were it not for resource and information constraints. Water harvesting typically requires investments on input materials and labour, which can be prohibitively costly. This is especially so for female farmers who exhibit a markedly lower adoption rate (38%) than their youth and male counterparts (45% and 50% respectively). Twenty-four percent of all households practise some form of soil conservation. This involves preserving soil conditions, maintaining water content with mulching, planting shade trees, and using manure. Many farmers use improved irrigation technologies such as pumps, canals, and water tanks to protect themselves against drought and heat. Women are more likely than men or youth to establish farm plots with irrigation systems. This may in part be due to division of farm labour that emphasizes women's role in crop production and water acquisition.

The underlying factors that exacerbated these hazards include: farmers' lack of awareness; poor planning at the programme as well as at the farm level; reluctance to seek climate information; non-response to (EWS); poor implementation of mitigation strategies like

flood control gabions; improper housing of animals; improper storage of animal feeds; poor dissemination of EWS, for example late alerts for floods; and lack of resources to respond to the hazards.

Adaptation strategies within the livestock sub-sector vary depending on climatic hazard. For drought and high temperatures, the farmers consider water conservation through water pans, drilling boreholes, or rearing more tolerant animals such as camels and goats that can survive longer without water. Pastoralists sometimes move animals towards riverine areas so that they have better access to water and pastures. Agro pastoralists will grow fodder and natural pasture along riverine areas when the hinterland is very dry. Other farmers use supplemental feeding, using fodder sources such as pods from Mathenge plant. Some farmers will reduce stock by selling. In particularly severe drought situations, farmers may even be forced to use the traditional culling system which involves eliminating the calf so that the cow can obtain enough resources to survive (“killing the calf to save the dam”). Pastoralists are known to use herd management strategies where milking animals are left near the homestead as the others move farther away in search of pasture and water. They may also migrate within the county, to other counties, or even cross into the Republic of Somalia in search of better grazing land.

Farmers also use value addition practices such as boiling and cooling milk using local equipment, bulking milk for sale, or using traditional preservation methods like susa (fermented milk). Alternatively, farmers may borrow money from informal financial institutions, friends, and relatives. When pastoralists migrate, especially heads of households, they organize the rest of the family to get goods on credit from local shops which they repay afterwards. Others may choose to diversify their income-generating enterprises, including pursuing alternative livelihoods. In Garissa, this commonly includes acting as intermediaries by sourcing milk from other farmers, especially in the hinterland, and later reselling it through milk outlets and in open markets to earn profit and supplement household income. Other alternative income- generating activities include burning charcoal, in particular the Mathenge plant, or cultivating non-traditional crops.

Many of the adaptation practices aimed at the post-harvest phase of production, including enterprise diversification, food storage and value-added activities, are mostly practiced by women. Women may play an important role in diversification of livelihood strategies. Annex 4 presents these and other strategies adopted in Garissa to counter the effects of climate change based on the farmers’ knowledge and tradition.

Off-farm services

Off-farm services such as EWS, insurance schemes, extension and training, credit and financing, storage facilities and market information, are offered to farmers to increase their climate adaptive capacity. Such services are offered by various actors, from county government (such as the meteorological, veterinary, agriculture, fisheries and livestock departments) to organizations like the Kenya Red Cross, the National Cereals and Produce Board (NCPB) and the National Drought Management Authority (NDMA).

Insurance services are still very limited in the county. The most vulnerable populations are the small- scale nomadic pastoralists and the agro-pastoralists, as the losses incurred due to drought or flooding are sometimes very high and farmers’ coping ability is severely constrained. For the main value chains identified in Garissa County, the activities at the production level are most gravely affected by lack of insurance services. Insurance services are offered with direct reference to the type of farming system. For this reason, nomadic pastoralists find it impossible or extremely difficult to access insurance, as frequent drought conditions throughout the county and country render their work very highly risky. Similarly, formal credit facilities that could help in supporting production activities are very limited. The credit options offered by most financial agencies like banks are generally not contextually appropriate as adherence to Islamic teachings prohibits interest-based credit. At the same time, lack of collateral for most low-income farmers limits their access to even sharia-compliant credit options.

On the other hand, extension services are amongst the most widely used off-farm services and are accessed by about half of all farmers. Although about 50% of farmers have accessed extension services, this does




In terms of post-harvest services, the most commonly used post-harvest storage facilities are traditional and located within the homestead. These facilities tend to be less efficient and often result in the loss of produce to pests and spoilage. The formal storage facilities are the National Cereals and Produce Board (NCPB) with a capacity of 4,500 tonnes. However, the NCPB facilities are used mostly for relief food storage. Post-harvest, value-added activities are undertaken mostly with milk, chevon, beef, mutton, and hides and skins. Value is added to milk products through processes such as boiling and fermenting to create alternative dairy products. Beef, chevon, and mutton are processed using “nyirinyiri”¹² in which meat is preserved by frying or keeping under fat, differentiating the various parts, salting, and drying. For crops, the main value-adding activities centre on cereals and include de-hulling and production of flour. Vegetables are graded and dried (42% and 50% respectively). Fruits are sometimes made into juice (57%) while fodder is often chopped (75%) and bailed (25%).

for livelihoods. However, county-wide uptake of the information that the PSPs generate is still low; the overwhelming majority of farmers continue to rely on indigenous traditional knowledge. Farmers argue that the PSP information is often not timely and accurate.

12 Nyirinyiri is meat that is dried /fried and preserved by deep frying in fat to enhance its shelf- life. It is commonly found in the dry regions across the country.

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

Camel (milk)

	Provision of inputs 	On-farm production 	Harvesting, storage and processing 	Product marketing 
 High Temperatures	Decline in pasture quality and quantity; heat stress on animals; high milk spoilage	Low feed intake, animal vigour and productivity; reduced animal weight gain, and reproduction; upsurge of diseases including Trypanosomiasis, Pester Pester Ruminater (PPR), Contagious Bovine Pleuropneumonia (CBPP), Pestes des Petits Ruminants (PPR)	Low milk quantity / insufficient quantities for bulking; reduced milk quantity; reduced milk quality; increased costs of operations for milk cooling	Low milk volumes; low milk volumes for sale on market
Magnitude of impact	Major-Severe	Major-Severe	Major-Severe	Major-Severe
Farmers' current strategies to cope with the risks	Pasture and fodder production (natural pasture); water harvesting using micro structures (interval watering); use of local equipment (can/with cloth)	Feed supplementation using salt licks and available fodder	Traditional milk preservation methods (e.g. use smoked containers to control bacterial fermentation)	Milk marketing groups, milk hawking and selling in local open air market; use of organoleptic and ocular tests for Quality assurance
Other potential options to increase farmers' adaptive capacity	Drought tolerant pasture varieties; formulate feed from local sources	Integrated herd management to encourage pasture re-generation; pasture/fodder banks to conserve pasture; improved animal breeds	Processing, value addition, packaging; milk storage in specialized cans, coolers, deep freezers	Cooperatives to promote aggregation, resource sharing and improve bargaining power; promote sale of milk in designated sheds use of testing equipment
 Droughts	Decline in pasture quality and availability; decline in water quantity and quality	Low animal vigour and productivity and loss of livestock; disease outbreaks from contaminated water	Low milk outputs/ insufficient quantities for bulking	Low milk sales and volatile markets; loss of income
Magnitude of impact	Major-Severe	Severe	Major-Severe	Severe
Farmers' current strategies to cope with the risks	Migration to grazing zones reserve; desiltation of available water pans	Emergency livestock feeding on supplements Destocking and culling of non breeding livestock	Bulking of milk for sale smoking of milk products to increase shelf life	Informal financing/borrowing, grants
Other potential options to increase farmers' adaptive capacity	Pasture conservation through hay/fodder banks; seed bulking to provide seed for pasture reseeded programs; WUA to formulate and enforce regulations/policies on water use and protect water catchments; access to grazing reserves in times of drought	Strategic feed stores along water corridors; supplemental feeding; watering troughs at watering points to improve on water sanitation	Set up cottage and small-scale milk processing facilities to produce diverse milk products e.g. yoghurt; cooling facilities for holding milk in bulk quantities	Group marketing of milk; links between farmer groups and financial institution for resource mobilization; livestock insurance programs

Cattle (meat)



Provision
of inputs



On-Farm
production



Harvesting,
storage and
processing



Product
marketing



Floods

Loss of pasture areas
water logging and soil
erosion; increased
waterborne disease
outbreaks

Animal malnutrition and low
body condition due to low
feed intake; increased
incidences of animal
infections and death

Low quality meat and meat
products; reduced
production

Low carcass price; loss of
income

Magnitude of
impact

Major-Severe

Major

Severe

Major-Severe

Farmers' current
strategies to cope
with the risks

River bank protection
through tree planting;
channelling of water in
common dams/small dams

Soil conservation measures
(Terracing, gabion, Fanya juu
terracing); pest and disease
management through
vaccination and pest control

Infrastructure improvements
(e.g. grade access roads
leading to slaughter house)

Other potential
options to
increase farmers'
adaptive capacity

Construction of
dykes/ditches along the
rivers; construction of big
dam (40.000m³) to prevent
flooding

Fodder / tree/ grains planting
on the terraces; upscaling of
traditional preservation
methods like Nyirinyiri

Improved road infrastructure
for fast movement of
livestock; re-introduction of
livestock auctions to cushion
farmers from animal loss.

Livestock insurance
programs; creating
small/fish ponds within the
farm to diversify farm
production



Droughts

Changes in feed quantity and
quality
Increased disease incidences
Reduced water availability

Reduced weight gain, poor
body condition and low
reproduction
Increased cost of
production due to disease
management
Increased incidences of
animal and human food
contamination

Reduced meat; increased
processing costs due to
the need of alternative
sources of water

low sales of processed
meat; low quality meat on
the market

Magnitude of
impact

Moderate-Severe

Major-Severe

Moderate-Major

Moderate

Farmers' current
strategies to cope
with the risks

Pasture conservation on
farm; construction of water
pans and boreholes; internal
and external disease and
pest control through
vaccination

Sell off animals to reduce
herd and stock sizes; reduce
number of watering days for
livestock; renovate existing
abattoir/slaughterhouse

Reduced quantity of
processed meat;
use of local meat
preservation techniques

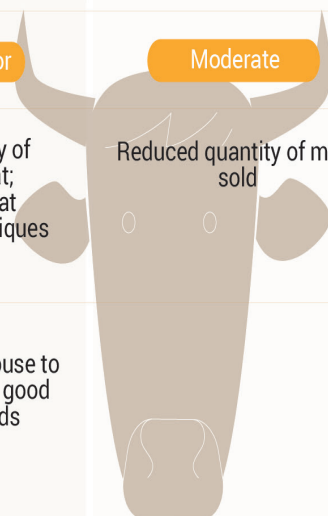
Reduced quantity of meat
sold

Other potential
options to
increase farmers'
adaptive capacity

Growing and stocking of
grains, maize, stover and
other fodder; initiate water
piping programs and drilling
more boreholes; keep
drought-tolerant livestock
like camels

Introduction of disease
resistance breeds;
enhancing controlled
breeding during droughts;
establishing meat
processors; breed
improvement through
selection for climate related
shocks; use of solar- and
wind-generated pumps to
abstract water from
boreholes and big water
tanks; capacity building on
camel husbandry

Use of
abattoir/slaughterhouse to
ensure and enforce good
hygiene standards



Fruits and vegetables



Provision of seeds and other inputs



On-Farm production



Harvesting, storage and processing



Product marketing



Floods

Destruction and loss of established crops and irrigation infrastructure; river banks erosion

High costs of production incurred for labour and fuels to relocation and rehabilitation of farm machinery and infrastructure. Delays in land and crop management practices because farmers can't access the farms

Loss of yields; poor quality produce due to spoilage.

Increase in produce price; loss of incomes

Magnitude of impact

Severe

Moderate-Major

Major

Major-Severe

Farmers' current strategies to cope with the risks

Early and fast maturing crops (e.g. cowpeas, watermelon); certified, local seedling nurseries

Improved production practices such as timely planting, conservation agriculture, certified seedlings, use of manures; opening up of farm access roads; strengthening river banks

Cleaning, sorting and grading of produce; sourcing from outside county out growers

Capacity building in food safety and handling

Other potential options to increase farmers' adaptive capacity

Green manure/drip irrigation; multi-storey gardening

Shade net technology to screen insects and reduce infections

Cold storage facilities. Forced ripening with ethylene and preserving through drying; build marketing sheds for fruit and vegetable products; packaging and branding of produce



Droughts

Increased pest and disease incidences; reduced soil moisture; increased wildlife-farmer conflicts

Increased production costs for irrigation, labour and use of pesticides; reduced plant vigour and stunted growth
Increased livestock/wildlife-crop farmer conflict over forage

Reduced yields; quality from spoilage

Low prices at farm gate

Magnitude of impact

Major

Major

Moderate-Major

Moderate-Major

Farmers' current strategies to cope with the risks

Early maturing and drought-tolerant crops (e.g. cowpeas, watermelon); use certified seedlings

Timely planting
Conservation agriculture; irrigation and manure application

Fruit and vegetable cleaning, sorting and grading at harvest

Food safety and handling standards

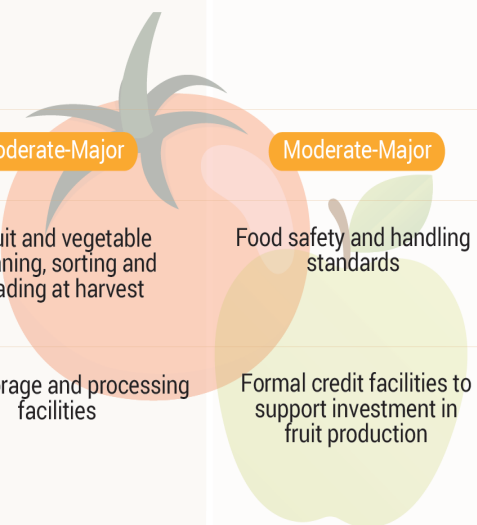
Other potential options to increase farmers' adaptive capacity

High yielding seed/crop (hybrid Kilele F1, Rio-grande); Establishment of Kitchen Gardens e.g. multi-storey gardens; develop gravity fed large irrigation schemes

Early warning information to guide decisions in planting irrigation and harvesting; enhance extension services to support new technologies; formal credit facilities to support investment in fruit and vegetable production

Cold storage and processing facilities

Formal credit facilities to support investment in fruit production



Cereals

Provision of seeds and other inputs

On-Farm production

Harvesting storage and processing

Product marketing



Floods

"Crop damage and loss from water logging; damage of infrastructure market sheds; increase disease incidences

Delayed crop husbandry practices; delays in supply of inputs and harvesting, high incidence of aflatoxins accumulation in cereals

Decreased yields of cereals; yield loss; reduced crop quality

Shortage of the commodities in the market (low supply)

Magnitude of impact

Moderate-Major

Major

Major-Severe

Moderate

Farmers' current strategies to cope with the risks

Use of cropping calendar to guide on what to purchase/procure; early procurement of inputs

Early warning systems on expected flood occurrence and duration to guide crop management decisions; timely stocking of cereals seeds by the stockists; avoid planting on the flood prone areas and plant when flood recede

Early crop harvesting at physiological maturity; use of donkey carts for transportation

Increasing the market prices due to low supply; grain banks at farm and community level

Other potential options to increase farmers' adaptive capacity

Diversification of crop types, changing planting dates

Irrigation land away from the river banks-hinterlands; direct excess flood water to irrigated farms for integrated farming; staggered planting of maize so as to produce when other areas have no green maize; make use of rain and boost with irrigation to reduce cost of production

Use of group transport vehicles; On-farm processing and Value addition

Controlled prices through establishing production policies



Droughts

Reduced soil moisture to support plant growth; increased farmer livestock-wildlife contact and conflicts over forage and water; high incidence of storage pests; unscrupulous supply of uncertified seeds (fake seeds) during drought recovery stage

Stunted crop growth (thin and falling crops); increased prices of inputs

Total crop failure; reduced grain quality from pest damage; reduced income from cereals farming

Magnitude of impact

Moderate-Major

Severe-Major

Major-Moderate

Moderate -Major

Farmers' current strategies to cope with the risks

Drought-tolerant crop varieties; seed selection and storage for planting; outreach programmes for inputs near the farmer communities

Early planting and guarding and scaring of birds, wildlife to avoid loss

Sun drying to reduce grain moisture content before storage; diversification of crop enterprises; consumption of green maize

Individual produce marketing; immediate marketing of product after harvesting

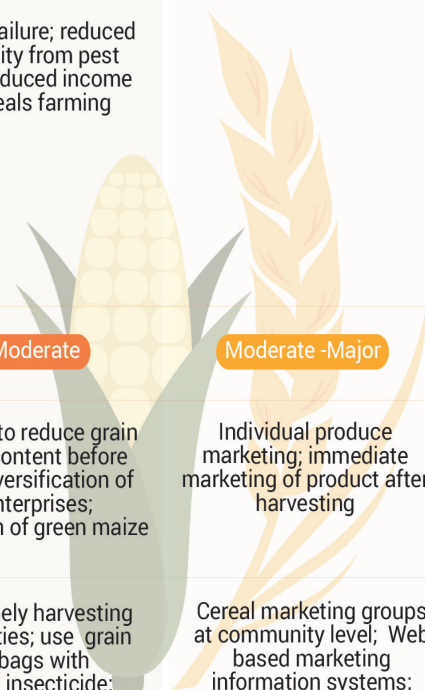
Other potential options to increase farmers' adaptive capacity

Research and breeding of drought-tolerant crops for Garissa county; use of water-harvesting technologies e.g. Zai-pits; establishment of community-owned agro input shops

Climate field schools to develop local cropping calendar and to disseminate climate information; boost maize production with irrigation and use manure for moisture conservation

Early and timely harvesting of crop varieties; use grain storage bags with pre-treated insecticide; introduction of bulking and collection centres with grain drying facilities; use of grain moisture meters to ensure correct storage moisture content and avoid aflatoxin contamination.

Cereal marketing groups at community level; Web based marketing information systems; introduction of cooperative for collective marketing; credit and financing for investment in grain farming.



Policies and Programmes

Awareness of policies and programmes related to climate change and adaptation is very limited. However, several national and local policies and programmes have been put in place to broadly address problems related to the climate vulnerabilities discussed previously.

The Adaptation to Climate Change in Arid and Semi-Arid Lands (KACCAL) seeks to promote development of capacity in managing climate-related risks through long-term adaptation strategies. For the major value chain commodities the programme supports production, farmer organization, value addition, and enhanced marketing. Farmers organize themselves into groups for production and marketing benefits. Also, through the Agriculture Sector Development Support Programme (ASDSP), farmers have been trained on crop selection, the importance of using improved seeds, and growing early-maturing varieties. The Wildlife Conservation and Management Act of 2013 was established to compensate any personal injury or destruction of property by wildlife. Inasmuch as the policy clearly outlines the process of compensation, the effectiveness of this policy has often been questioned by the local people following many claims that have never been compensated. The ineffectiveness was attributed to lack of appropriate wildlife monitoring mechanisms by the Kenya Wildlife Service (KWS).

In the livestock sector, the unwritten rule of destocking aims at reducing environmental degradation and promoting sustainable resource utilization. Pastoralists are encouraged to keep few high-quality animals as well as sell the animals early enough during the dry season before the animals' condition becomes poor. The institution helps in ensuring quality livestock and livestock products so as to enhance marketability. The main challenge to this rule is the cultural practice of overstocking, as owning many animals is considered prestigious. Consequently, the pastoralists have a tendency to avoid selling the livestock even during severe droughts. It is therefore pertinent that the pastoralists are trained on the benefits of destocking. In addition, a policy restricting movement of animals to public areas, such as schools, aims to reduce cases of diseases that can be transmitted from animals to human beings and livestock disease outbreaks. The veterinary department vaccinates the animals once the permit to move is granted. However, many pastoralists move their animals at night, making monitoring of livestock movements difficult.

Other programmes in the livestock sector include growing pastures under irrigation. This programme started in 2014 and is supported by the Food and Agricultural Organization

(FAO) and the County Livestock Production Department (LPD). Its objective is to increase availability of pasture so as to reduce instances of the pastoralists migrating with animals. It promotes production of hay during the wet season and storing for use during the dry season. It was reported that the hay is less palatable to the animals and that the pastures produced are not sufficient due to lack of irrigation water and storage facilities.

The County is preparing a climate bill, aimed at improving coordination of climate change activities including funding. A proposal to allocate 1% of the budget to climate change-related activities is in the bill. The Irrigation Policy forbids cultivation within 30 meters of a river. The purpose of the bill is to prevent destruction of crops and soil degradation that result from flooding. However, farmers have traditionally lived and cultivated their land close to the river; it is therefore difficult to change such cultural habits. Such measures are complemented by the Agroforestry Policy. The policy encourages farmers to plant perennial crops such as mangoes so as to increase vegetative cover and support soil conservation efforts. Cross-cutting policies include the Kenya Forestry Act under the Kenya Forestry Service (KFS), which mainly promotes afforestation. Scarcity of water makes it difficult to achieve a 10% forest cover. In addition, there is no clear enforcement mechanism, and no budget is allocated for implementation of the policy.

There are major bottlenecks in terms of enforcement of the above-mentioned policies. These arise from the fact that most of the policies are designed at the national level and as such may not be custom made for the county. The social setup in the county also poses a major hindrance to effective enforcement of the policies. In addition, due to inadequacy of frequent monitoring and evaluation of the programmes in the county, the intended beneficiaries may never benefit from the interventions. This is mainly as a result of corruption, a factor that was reported to be a major hindrance to development.

Governance and institutional resources

There are various government, non-government (NGOs), community-based, faith-based and private organizations in Garissa County that directly or indirectly deal with climate risks. The government institutions at the county level include the LPD, Agriculture Department, Irrigation Department, the Agricultural Training Centre (ATC), Kenyan Meteorological Department (KMD), the National Environmental Management Authority (NEMA), the

National Cereals and Produce Board (NCPB), and the National Drought Management Authority (NDMA). The government departments and organizations are mainly for extension, input provision, and policy support. Specific interventions include extension and vaccination services by the veterinary department, and the design, implementation, and mainstreaming of risk reduction strategies, as well as coordination of drought management infrastructure by NDMA. Improving resilience through sorghum growing supported by NDMA

Key international organizations working in Garissa County in areas related to addressing food security issues, supporting agricultural development and providing capacity building services include Kenya Red Cross (KRC), the United Nations' World Food Program (WFP), and FAO. Non-governmental organizations (NGOs) focus mainly on advocacy and capacity building. The NGOs with the largest presence in the region that address issues related to climate change adaptation and food security include Womankind, which provides capacity building for rural women, and African Development Solutions (ADESO), which provides training programmes. Also organizations including Care Kenya, Kenya Camel Association (KCA), Kenya Industrial Research and Development Institute (KIRDI) and Accelerated Value Chain Development (AVCD) have contributed on issues of climate change in the county.

For the government departments, influence mainly comes from the national offices. Nevertheless, when it comes to planning and implementation of development interventions, the government departments in the county and NGOs have significant influence on the choice of approach and location of interventions. Some donors also have specific objectives which may not allow for adjustments at the county level. The source of funding also influences operations in that some sources encompass a lot of bureaucracy hence delaying operations. Other than planning for development interventions, the government departments also take part in responding to emergencies that are within their mandate. Since these emergencies tend to be recurring, plans, policies, and strategies are often made in collaboration with specific department sub-sectors (programme wings) prior to, and in anticipation of, emergencies. Coordination among these previously mentioned organizations exists at some stages of intervention design and implementation. Collaboration was noted within the government departments. However, NGO to NGO collaboration and NGO to government department collaborations could be strengthened. This may be due to the fact that most of these NGOs are autonomous in operation.

Synthesis and Outlook

As drought and flooding are foreseen to occur with greater frequency in Garissa County in the future, enhanced capacity of farmers to cope with these new conditions are needed. This involves critical short-term and long-term adaptation measures that target production systems and value chains key to the population's food security and livelihoods, including livestock and crop systems.

Significant initiatives to increase resilience in the agricultural sector have been evident in Garissa. These include on-farm practices that target water and soil conservation and management, such as water pans, crop rotation, agroforestry systems, and drought-resilient animal breeds. In addition, off-farm services and programmes have been provided to act as enablers for uptake of adaptation options such as provision of EWS, extension services, and technical support (building of small-scale irrigation pumps).

It is important to continue implementing such initiatives and supporting them through actionable policies and strategies. However, integrated agricultural development requires adaptation measures that target the entire value chain activities. While on-farm production is important, without ensuring enabling conditions for input provision and access (seeds, fertilisers, pesticides), product storage and market access, farmers' livelihoods and incomes remain at risk, since climate hazards are expected to affect all important value chain activities. Distribution of the inputs (seeds and fertilisers) should be timely and synchronised with rain cycles given the claims by farmers that the inputs are never available during onset of rains. This can be achieved through construction of more input outlets and collaboration with the meteorological department. Of particular importance also are investments in road infrastructure that can enable farmers' access to market, but also to important services such as extension and veterinary support. Moreover, value addition, through fruit juice, smoked and/or dry meat, processed milk, among others, can open up new niche markets for farmers.

Apart from these, a long-term vision for the agricultural sector requires addressing underlying factors that continue to increase farmers' vulnerability and diminish their capacity to carry out climate adaptation activities more effectively. Investments in basic public services such as availability of and access to potable water, electricity, and education could help curb persistent, high poverty and illiteracy levels among farmers. These would enable them to invest in

activities that secure their livelihoods and to access and adequately use vital agricultural inputs (notably s, vaccines, irrigation equipment) that could maintain and eventually increase productivity and ultimately incomes.

An enabling institutional policy and governance environment is also critical for addressing climate vulnerabilities of farmers. The formulation and implementation of county-level climate change action plans that are grounded in local needs and resources assessment could represent an important step towards the operationalization of the country's climate strategy. Furthermore, increased alignment of public and private funds intended for agricultural development to the

sector's needs and relevance for local and national economy and food security would enable a better functioning of the institutions. Currently the institutions lack sufficient resources to effectively deliver services such as climate information, extension, veterinary support, and subsidies. It would be useful to explore alternative ways of communicating climate information and venture into mass media (radio for instance) in offering extension.

Promotion of collective action can further strengthen the existing local norms such as communal land ownership for activities like community seed nurseries.

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

Annex 1: Quantity and value of production of livestock and crop products in Garissa County

Annex 2: Productivity of main fruits and vegetables

Annex 3: Climate analysis

Annex 4: Selection of adaptation strategies in Garissa County

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