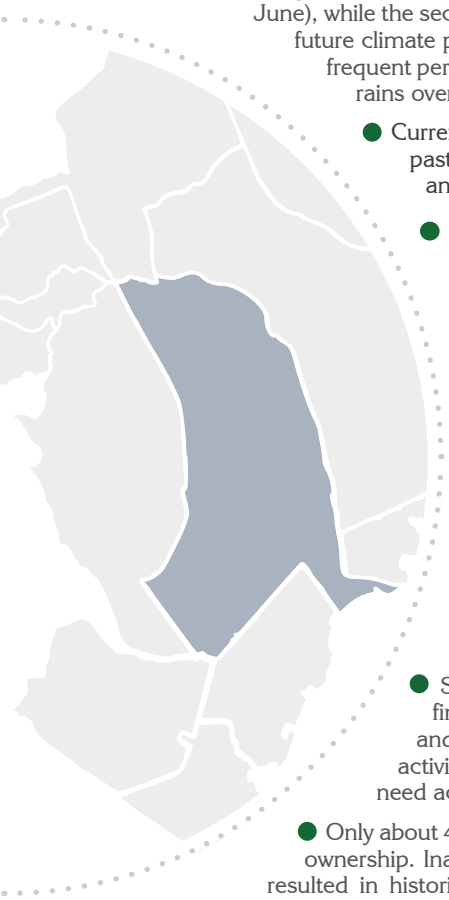
Climate Risk Profile
Tana River County

Highlights

- Agriculture and livestock production are the main sources of livelihood in Tana River. They contribute about 82% of household incomes and more than 80% of employment. Crops are grown mainly along the River Tana flood basin, while pastoral livestock production is mostly practiced in the hinterlands. Sixty-seven percent of the county´s population is food-insecure and relies on food aid every year. This is mainly because the land's potential has not been productively exploited. Additionally, climate variability and change is taking its toll on agriculture.



- Over the past four decades, a slightly increased tendency in drought hazards has been observed in the first wet season (January-June), while the second wet season (July-December) was characterized by heavier and more frequent precipitation. Models of future climate projections show that Tana River County will remain highly susceptible to drought and flood events. More frequent periods of drought are expected in the First season, while the Second season is more likely to be hit by intense rains over the next decades.

- Current adaptation strategies to climate hazards for livestock systems include irrigated pasture production, pasture conservation, mass vaccination, rangeland pasture establishment, destocking, livestock migrations, and rearing livestock types adapted to drought such as goats and camels.

- Adaptation strategies for crops include early harvesting, staggered cropping, planting early-maturing crops, irrigation, planting drought-tolerant crops such as cowpea and green gram, and flood recession planting. Forests are being conserved through agro-forestry, controlling deforestation, and promotion of energy-saving *jikos* among other interventions. Water harvesting and conservation is being promoted through construction of shallow wells, boreholes, and irrigation canals to increase access to water.

- Off-farm services such as early warning systems, insurance schemes, agricultural extension and training, credit, storage facilities, and market information are offered to farmers to increase their climate-adaptive capacity. Such services are offered by stakeholders such as the Kenya Meteorological Department (KMD), the Ministry of Water and Irrigation (MoWI), the Ministry of Agriculture, Livestock and Fisheries (MoALF), the National Drought Management Authority (NDMA), and the Kenya Red Cross (KRC). However, the capacity of these stakeholders to effectively deliver the services is constrained.

- Despite the on- and off-farm efforts, farmers' and pastoralists' adaptive capacity is very low. Poverty and illiteracy levels are still very high, and the average distance to a water source is still very long (about 10 km from grazing areas).

- Successful implementation of climate adaptation strategies requires strengthening of the institutional and financial capacity of the stakeholders mentioned above. This will enable them to deliver basic resources and agricultural incentives to the target beneficiaries and thus keep them engaged in sustainable agricultural activities. Farmers need information to understand the urgency for adapting to climate change.Therefore they need access to appropriate extension services in a timely manner.

- Only about 4.3% of the land in Tana River County has been issued with title deeds, while most land is under communal ownership. Inadequate demarcation of land for conservation, grazing, livestock migration, and crop production 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.

- At the moment, about 60% of the youth in the county are engaged in agricultural activities, mostly through livestock rearing (94%). At the same time, women tend to have a greater role in growing nutritious food such as native plants (green gram and cowpea) and staple foods such as maize. Youth and women are among the most vulnerable groups in the county, with the lowest adoption rates of adaptation strategies. This suggests a need to target interventions that incentivize adaptation strategies among these two groups.

KAPP
Kenya Agricultural Productivity Programme
Republic of Kenya
WORLD BANK GROUP

List of acronyms

ASDSP	Agricultural Sector Development Support Programme
AEZ	Agro-ecological Zone
APHIAplus	Population and Health Integrated Assistance
ASAL	Arid and Semi-Arid Lands
CCP	Contagious Caprine Pleuropneumonia
CIAT	International Center for Tropical Agriculture
CRS	Catholic Relief Services
ECF	East Coast Fever
FAO	Food and Agriculture Organization of the United Nations
GAA	German Agro Action
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 Livestock Development Programme
KES	Kenyan Shillings
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
MoLAI	Ministry of Lands, Agriculture and Irrigation
MoALF	Ministry of Agriculture, Livestock and Fisheries
MDNKOAL	Ministry of State for Development of Northern Kenyaand Other Arid Lands
MoWI	Ministry of Water and Irrigation
NALEP	National Agriculture and Livestock Extension Programme
NCCAP	National Climate Change Action Plan
NCCRS	National Climate Change Response Strategy
NDMA	National Drought Management Authority
NEMA	National Environmental Management Authority
NIB	National Irrigation Board
RVF	Rift Valley Fever
UN	United Nations
UNDP	United Nations Development Programme
VCCs	Value Chain Commodities
WB	World Bank
WCMA	Wildlife Conservation and Management Act
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 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.

In 2010, Kenya developed a National Climate Change Response Strategy (NCCRS) which recognized the importance of climate change impacts on the country's development. This was followed by the National Climate Change Action Plan (NCCAP) in 2012. Since the focus of these initiatives has been the national level, there is a need to mainstream climate change perspectives in programmes and development plans at the county level.

To strengthen local capacities 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 Tana River County, where climatic events in the recent past hit the agriculture sector significantly. In 2008, it was reported that the River Tana changed its course endangering thousands of livelihoods. The change led to water scarcity along the areas in its original course and floods in the areas along the new course[1]. In 2011, a person was reported to have died in a collapsing well while searching for water[2] following a serious drought in that year. In 2012, a rainfall failure that resulted in water scarcity led to inter-communal feuds over pasture land and water resources between the Pokomo and the Orma; the dispute left 150 people dead (Environment, Conflict and Cooperation Platform, 2012). In 2015 and 2016 more than 4,040 families were displaced by the Tana River County floods in Gubani, Masabubu and Tana Delta.This event led to an increase in number of internally displaced people. Up to 88 camps were established in December the same year. Roads and schools were destroyed and economic activities disrupted. Up to 73,000 people suffered food insecurity and depended on relief food[3].

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. This includes scientific assessment of climate indicators for dry spells, flooding, and heat stress among other key hazards for agriculture. 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 According to Irinnews (2008).
2 According to Irinnews (2011).
3 According to The Star (2015) news.

Agricultural context

Economic relevance of farming

Tana River County covers 38,682 km^2 and is located in Kenya's coastal region. It borders Isiolo County to the North, Kitui County to the West, Lamu County to the South East, Garissa County to the North East, and the Indian Ocean to the South, and has a coastal strip of 35 km. One of the important natural resources in the county is the River Tana, Kenya's largest river, which flows through the county as it drains into the Indian Ocean. The river also forms the Tana River Delta, a wetland that covers about 1,300 km^2 and supports more than 100,000 inhabitants (Leauthaud et al., 2013) (see Annex 1 for a description of the administrative division of the county).

The county is largely rangeland, receiving low and erratic convectional precipitation. The average annual rainfall is about 280 - 900 mm (GoK, 2014a)[4]. Rainfall is bimodal; the long rains come in April to May (First Season) and the short rains in October to December (Second Season). Because the rainfall is conventional, the coastline is wetter than the hinterland. The temperature ranges from a minimum of 23°C to a maximum of 38°C (KIRA, 2014)[5].

The county is parcelled out into four agro-ecological zones (AEZs) (Mulaa et al., 2005, Jaetzold et al., 2010) (See map in Annex 1):

- The coconut-cassava zone (also known as CL3), ranges from 1 to 10 meters above sea level (Kipini);
- The cashew nuts and cassava zone (also known as CL4), ranges from 1 to 50 meters above sea level (Kipini),
- The low land - livestock zone (also known as CL5), ranges from 1 to 60 meters above sea level (Lower Garsen)
- The lowland ranching zone (also known as CL6), ranges from 20 to 100 meters above sea level (all other divisions apart from Kipini)

Despite the dry conditions, agriculture is the main income-earning activity in the county, contributing roughly 82% to the household incomes (GoK, 2013a)[6]. In 2012, earnings from major crops[7] and livestock products[8] were estimated at about 4.4 and 1.7 billion Kenyan Shillings (KES) respectively. Still, a large proportion of farming is particularly aimed at meeting daily household consumption needs.

The sector employs more than 80% of the county population. According to a survey undertaken by the Agricultural Sector Development Support Programme (ASDSP) in 2013, 84% of all men, 33% of all women, and 60% of all youth in the county were employed in agriculture. Approximately 94% of the livestock labour force is composed of youth, while 75% of crop farmers are men. Women farmers mainly grow native crops such as cowpea and green grams as well as the dominant staple in the country, maize.

Only 6% of the total land is under crop farming, mostly in the riverine area of the Tana River County, as the hinterland is drier and mostly dedicated to livestock farming. With the economic livelihoods of the county being closely tied to agriculture and climate, the hot and dry conditions make the areas away from the Tana River County highly vulnerable to years with low precipitation, as was the case in 2011 and 2012. The riverine and delta areas are highly vulnerable to flooding in years with high precipitation as was the case in 2014 and 2015.

People and livelihoods

Because of its vast and underprodcutive area, the Tana River County is sparsely populated, with a total population of 262,684 reported in 2012 (GoK, 2014). The gender distribution is equal (50% women, 50% men) and the youth population (aged 15 to 30 years) is about 27%. The population is expected to grow by about 2.8% by 2018. This high growth is attributed to the low utilization of contraceptives due to strong religious beliefs that discourage family planning, and a relatively low child mortality rate of 5.1%.

4 The annual rainfall data is a year to year average.

5 The temperature figures differ from the values of 26.6° to 41°C reported in GoK (2013a).

6 The average per capita income in Tana River County is 9,127 Kenyan Shillings (KES), the equivalent of USD 90.

7 This figure doesn't include the value of maize, a major crop in the County.

8 Mainly beef (56%) and cow milk (10%).

Approximately 86% of the population is concentrated in rural areas. However, the proportion of those living in rural areas is expected to shift as people increasingly move to urban areas – notably in Hola, Madogo and Garsen, in search of employment.

The county is characterized by a very high level of poverty. The adult equivalent poverty headcount stands at 77%, compared to the national rate of 47% (KIRA, 2014). Low literacy levels, high unemployment and harsh climatic conditions are some of the factors contributing to the high poverty levels.

Despite proximity to hydroelectric dams on the River Tana and the county's potential to generate solar and wind energy, only 1% of the population has access to electricity. About 87.5% of the residents use firewood/ charcoal for cooking and 86.7% use paraffin for lighting. Access to water is also a big challenge; only 30% of the residents have access to potable water. The mean distance to a water source is 4 km[9] . The average distance from grazing areas to watering points has been reported to increase in 2016 to around 10 km. Most communities depend on water pans and natural rivers for both domestic and livestock water supply. The water problem is anticipated to be worse in future as many of the water resources have dried up due to high evaporation rates (NDMA, 2016).

Food poverty is estimated at 67%[10], indicating an over-reliance on relief food (GoK, 2014b). Food security is affected by low agricultural productivity, below normal and erratic rainfall, periodic outbreaks of livestock diseases such as East Coast Fever (ECF), and Contagious Caprine Pleuropneumonia (CCP), high poverty levels and the flat terrain that makes the county prone to flooding; flooding destroys crops when the gates of reservoir dams upstream are opened. It is estimated that female-headed households are the most affected by food shortages, due to low access to productive inputs and land.

The main livelihood activities in the county are livestock keeping, crop farming, and to some extent aquaculture[11]. Goats, camels, cattle, and donkeys are kept mainly by pastoralists, especially the Orma, Boran, Wardei, and Somali populations for milk, meat, hides and skins[12]. In 2012, cattle and camel milk presented the highest contributions to the county´s total income generated from livestock products at 62% and 31% respectively. Crop farming is mainly practiced by the Pokomo population and includes production of maize (43% of the cropland), rice (11% of the cropland), green gram, cowpea and banana, and others[13]. Of all the area under crop farming, food crops occupy a slightly larger area of about 2.9% compared to cash crops which occupy about 2.7% of the arable land (GoK, 2014).

Agricultural activities

Land in Tana River County is mostly non-arable, with only about 6.6% - equivalent to 254,700 ha being arable. Non-arable land is 3,179,870 ha, equivalent to 81% of the total land area, and land under national reserves and parks is 305,900 ha. Smallholder mixed farming is mainly practised in AEZs CL3 and CL4, whereas the CL5 and CL6 are mainly used for pastoral activities.

A large flood plain formed in the county due to seasonal flooding of River Tana forms the backbone of the county and varies in width between 2 and 4 km in some areas. It provides vast areas of land for cultivation and dry season grazing. Farming is mainly practiced along the riverine areas of River Tana and in the irrigation schemes of Hola, Bura and Tarda. The hinterland has seasonal streams (or lagas) that support wet season grazing. Farming is mainly rainfed, though farmers also practice flood recession farming and very few use irrigation, due to high costs of irrigation activities.

As of 2010, the area under irrigation in the county was approximately 1,350 ha, which accounts for only about 10% of the total irrigable area (GoK, 2013). Irrigation is mainly used for maize and rice production and a few cash crops such as coffee (Diop et al., 2016 pp112)

The average farm size in the county is about 4 ha, with relatively high regional variations: approximately 6 ha in the settlement schemes, 2 ha in the Ngao adjudication

9 A water source refers to either surface water such as rivers and underground sources such as boreholes, shallow wells and earth pans.

10 This figure, obtained from the Kenya National Health Survey is slightly different from the figure provided in the CIDP of 56.3%. Food poverty refers to the percentage of the population depending on relief food.

11 Households relying on fish farming represent only 3% of the total households in the County. The main types of fish include marine species, Claris and tilapia.

12 Major breeds include the Galla goat, the black headed Persian sheep, and the Orma-Boran cattle.

13 The percentages were obtained by taking acreage according to the county crops records and dividing with the total area under crops.

(CL5) area and between 0.4 and 3 ha in the irrigation schemes of Hola (CL4) and Bura (CL5). Only 4.3% of the land in the county has been assigned title deeds (GoK, 2014), given that most of the land is communal. The percentage of households with title deeds is higher among male-headed households compared to female- and youth-headed households, with a ratio of 3.5:1 (GoK, 2014a). Communal land ownership is most common among women. The communal land tenure hinders long-term investments on conservation. It also lends itself to inter-communal feuds, particularly during dry spells as different communities claim rights to the land.

Crop and livestock farmers in Tana River County use relatively low levels of agricultural inputs, mainly due to high prices of inputs, which arise as a result of the poor road infrastructure network and general low production of inputs in the county. Farmers normally utilize local and recycled seeds. Results from the ASDSP survey from 2013 showed that utilization of improved seeds is common for commercial crops like watermelon and cotton during the Long Rains Season (April and May), since it is the major crop growing season (GoK, 2014a). Field pesticides are used by 8% of the farmers in the county, storage pesticides by 7%, and herbicides by 10%. Compared to women and youth, men tend to use fewer inputs, given their engagement in pastoral livestock activities and continuous search for water and pastures.

Agricultural value chain commodities

A broad diversity of agricultural products is grown in Tana River County. Various value chains have been prioritized for development interventions by different government organizations and programmes such as the ASDSP, the Kenya Agricultural and Livestock Research Organization (KALRO), the 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). The VCCs selected are: maize, mango, green gram and goat meat. Maize was selected mainly for food security reasons, whereas goat meat, green gram and mango were selected for their economic importance. Annex 1 shows a summary of the indicators. Maize and green grams are grown in irrigation schemes of Bura (AEZ CL5) and Hola (AEZ CL4), and Kipini (AEZ CL3). Maize yields in the county are about 15 bags (90 kg bags) per acre, below the potential of about 20-25 bags (90 kg bags) per acre. Green gram productivity is similarly low given that an acre produces about 4 bags (90 kg bags) per acre, against the potential of 5-6 bags (90 kg bags) per acre. Mango on the other hand is produced along the River Tana, from Madogo to Kipini (in AEZs, CL5, CL4 and CL3). The current productivity for mango is about 3 tonnes per acre, though there is a potential of up to 5-6 tonnes per acre. Meat goat is kept throughout the county mostly in AEZs CL4, CL5, and CL6.

Livelihoods and agriculture in Tana River County

Demographics

0.6% Of Kenya´s population

262,684 inhabitants

86% Live in rural areas

50% 50%

Access to basic needs

77% of the population lives in **absolute poverty**

Potable water	30%
Electricity for cooking	0%
Electricity for lighting	3%
Education (youth literacy rate)	34%

Food security

56% of the population suffers from **food poverty**

ND of household **income spent on food**

ND People **undernourished**

ND Children **stunted**

0.1% 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)

Tana River

Farming

County´s farming area

254,700ha 8%

82% of the population employed in agriculture production

4% of farmers have title deeds

ND% are women

Farming activities

Food crops 3%

Cash crops 3%

Of county´s agricultural land

Livestock

0 Group ranch

5 Company ranches

Farming inputs

Water uses

ND ND ND

Fertiliser types (% of households)

NPK

3% Organic manure

2% Basal fertiliser

9% Top dress fertiliser

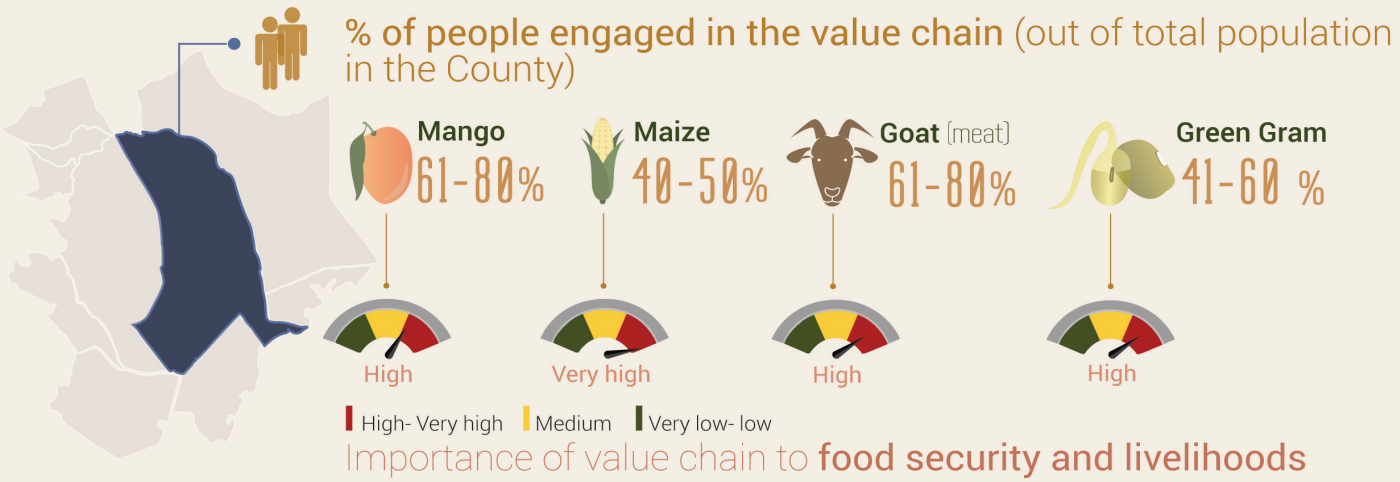
Pesticide types (% of households)

8% Field pesticides

7% Storage Pesticides

10% Herbicide

Agricultural value chain commodities in Tana River County



Maize

Maize is a key staple food for Tana River's population and a major contributor to livelihoods (See Annex 2). The crop is grown in both seasons by small-scale farmers in the irrigation schemes and along the River Tana. However, studies have shown that maize production is better suited to Kipini mainly during the Long Rains (Makenzi et al., 2013). Other areas in the county have low capacity in maize production. While male-, female- and youth-headed households alike grow maize on relatively small areas of land, female-headed households registered the highest productivity in the First Season and youth-headed households in the Second Season in 2013. The high productivity among female-headed households in the First Season is due to relatively high fertiliser utilization compared to men- and youth-headed households. In the Second Season, youth-headed households registered the highest productivity (see Annex 3). Youth are generally more likely to adopt new technologies such as high-yielding varieties. Productivity of men-headed households was the lowest in all the seasons due to low input use.

About 61-80% of the county´s population is engaged in the maize value chain. Farmers are involved in activities such as land preparation, weeding, harvesting, storing, and in some cases sorting and transporting. Despite the fact that several organizations such as NDMA, German Agro Action (GAA), KRC, County government and the Catholic Diocese of Garissa supply improved seeds to the farmers, utilization of recycled seeds is very high. This is partly attributed to a lack of incentives for farmers to continue using improved seeds, as well as limited access to seeds due to poor infrastructure and high prices. There is minimal value addition in the maize value chain given that the county lacks a milling facility. Marketing channels for maize depend on where the maize is grown. Farmers in the irrigation schemes mainly sell to the cereals' board through the National Irrigation Board (NIB) whereas those along the river banks mainly sell to brokers. Since 2014, the county government has also been buying maize from irrigation schemes and distributing it to food-insecure households as food aid.

Green gram

Green gram is grown for both commercial and household consumption. The value chain involves about 60% of the population in the county. The crop is grown in both seasons in the irrigation schemes of Hola, Bura and along the River Tana. Unlike maize, men-headed households registered the highest productivity in 2013, most likely due to men's increased access to extension services compared to women and youth (see Annex 3).

In the green gram value chain, the farmers mainly engage in land preparation, weeding, harvesting and spraying, value addition (storing, transporting, and bulking), and marketing. Various NGOs such as GAA,

Samaritan's Purse, and KRC offer farmers seeds. However, GAA in collaboration with WFP provide storage facilities whereas Samaritan Purse provides pesticides. In addition, the above-mentioned NGOs, in collaboration with the county government and the Ministry of Agriculture provide extension services to the farmers on input utilization, good agronomic practices, and storage. Market channels for the value chain are mainly brokers and sometimes schools.

Mango

Mango is mainly grown as a cash crop. Men make major decisions regarding mango production, such as planting and marketing. Orchards are dominated by tall and old trees. The crop is mainly grown along Tana River County with only 2% of the total land with mangoes being under irrigation. The most common local varieties are Punda and Dodi. These require minimal fertiliser and pesticide utilization. The youth group is more likely to apply manure to the mango trees. Lack of financial capacity to purchase inorganic fertilisers may be contributing to this scenario. The youth-headed households were also found to be more likely to compost manure compared to the male- and female-headed households (GoK, 2014a).

Productivity is highest among male-headed households, mainly due to the land tenure system, in which men are more likely to have a relatively secure tenure system that can enable production of perennial crops. In addition, low productivity among youth-owned farms could be attributed to their ownership of younger mango trees that have yet to produce high yields.

The mango value chain is mainly composed of farmers who produce, sell and add value, and brokers who serve as buyers. Mangoes can be sold by individuals and/or through cooperatives. Value addition by the farmers is largely transporting (an activity dominated by the youth) and bulking at collection centres. Processing is very low following the collapse of the mango-processing plant that used to be located in Boji. The farmer-acquired processing plant at Garsen cannot sufficiently handle the quantity of mangoes produced in the county. This has resulted in farmers drastically reducing their sales to brokers given that they have very little bargaining power.

Goat (meat)

About 75% of the county's households keep goats for meat as they can survive harsher climatic conditions compared to other livestock types. In 2014, there were about 693,350 meat goats in Tana River, producing roughly 382,749 kg of meat. The main goat breeds in the county include the Galla and the East African goat. Currently, male- and youth-headed households are most likely to own and slaughter goats.

The major actors in the value chain are pastoralists and the Livestock Production Department (LPD), which provides extension services on input utilization and practices such as production of hay. NGOs such as GAA, Population and Health Integrated Assistance (APHIAplus) and faith-based organizations including the Catholic Diocese supply inputs such as pesticides and provide technical advice on water harvesting.

The Veterinary Department and NDMA play an important role in the value chain as they help with disease control through vaccinations. Other initiatives include construction of a fodder warehouse and supply of grass seds by the United Nations Development Programme (UNDP), range rehabilitation initiatives through Food for Assets initiatives, National Agriculture and Livestock Extension Programme (NALEP), Kenya Dryland Livestock Development Programme (KDLDP), MoALF, Ministry of State for Development of Northern Kenya and Other Arid Lands (MDNKOAL), and NDMA. In marketing, brokers serve as the major marketing channel. Some of the goats are sold to local butcheries and others in markets outside the county such as Garissa, Malindi, Mwingi, and Kitui. Value addition activities undertaken by the farmers include Nyirinyiri (meat deep-fried and preserved under cooking oil), smoking, and drying.

Agricultural sector challenges

As mentioned above, agriculture is the main economic activity in the county, yet it is experiencing several production, economic, and social challenges. Crop and livestock productivity is very low. This is mostly due to harsh climatic conditions such as droughts (Makenzi et al., 2013) and floods, which also affect marketing of the agricultural products, given destructions of road infrastructur e and diminishment of product quality to be sold.

In addition, the high population growth rates have not only led to increased pressure on the natural resources, but also to increased poverty levels. As a result, farmers are not able to afford the optimum use of inputs, technology, agricultural information, financial services, and insurance. These challenges have increased rates of food insecurity among the local population due to insufficient access to food.

Low market access caused by poor road infrastructure is another important challenge to the sector. Lack of capacity to undertake value addition, and the lack of

storage facilities has forced farmers to sell their raw products to middlemen at very low prices.

The budgetary allocation for the agricultural sector in the county is very low (4.1% in 2012), a factor that may explain the inadequate service provision to farmers, such as extension. Farmers reported that most of their queries on pest and disease incidences go unanswered due to long distances to the agricultural offices that hinder frequent follow-ups. The relevant county offices lack capacity to undertake agricultural research within the county. For instance, soil samples have to be taken to the headquarters in Nairobi for analysis. Moreover, several interventions geared towards improving agricultural productivity such as construction of water pans and procurement of vaccinations have been affected by insufficient funding.

Agricultural production in the county is also challenged by competing demands for and conflict over natural resources. Cases of livestock invading croplands, especially during dry spells, are very common. Baboons, rodents, and wild pigs menace impact production of some crops especially root crops such as sweet potato and cassava, as well as water melons.

In addition, the current land tenure regime does not stimulate long-term investments and conservation measures such as agroforestry. This is due to non-excludability (impossible to restrict utilization to a certain group of people only) and free riding, which occurs when some members abscond from participating in conservation but still benefit from the efforts of other people.

The social norms and beliefs also hinder agricultural development. This is exacerbated by the low literacy levels in the county. Culturally, farmers with many livestock are considered wealthy and as such they command respect in the community. The common practice of keeping large herds and the reluctance to sell livestock decreases the herd's overall productivity and exposes pastoralists to the risk of losing the livestock during dry spells. The negative perceptions about financial institutions such as banks also limit credit accessibility and reduces acceptance of initiatives such as livestock insurance and other new technologies. Negative perceptions arise from the belief that these institutions are there to exploit farmers rather than help them.

Climate change and agriculture: risks and vulnerabilities

Climate change and variability: historic and future trends

Tana River County has a relatively dry and hot climate throughout the year. The average temperature is greater than 25°C throughout the county, with area on the western side of the county averaging over 27°C. Much of the county receives less than 500 mm of precipitation per year, and the rest less than 1000 mm per year. As such, heat stress, dry spells, and drought are hazards that strongly contribute to agricultural risk in the county. However, flooding along the Tana River County riparian areas is also an issue, especially due to periods of rain upstream in the Tana River County.

Experts and farmers alike acknowledge that there has been significant changes and variations in climatic conditions over the past years, affecting agricultural production and livelihoods in the County. Extreme weather events are very common in the county. Drought conditions have been experienced in 1975, 1976, 1980, 1981, 1983, 2001, 2004, and 2009 (Ngaina et al., 2014), where the Central and North regions of the county are the most prone, while areas along the River Tana are more prone to floods. Flood events in the county include those of 2002, 2003 and 2010 (Huho and Kosonei et al., 2014), and the recent flood events of 2015 and 2016 in areas such as Bura, Gubani, Masabubu and Tana Delta led to internal displacement of about 10,000 people and destruction of roads)[14].

The most extreme weather conditions tend to occur during July-December[15] Extreme precipitation above 20 mm in a day[16] occurred in seven years since 1981 during the second wet season. In contrast, January-June (first wet Season) experienced no years with a single day receiving over 20 mm of precipitation. This intense precipitation within Tana 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 County outside of the county are more important in causing flooding along the main stem

14 As reported by the Star Newspaper (2015).

15 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.

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

riparian areas of the Tana River County (e.g. Muranga County). Moisture stress and dry spells also occur more prominently during the second wet season (approx. 90 days of consecutive moisture stress), being about 20 days longer than in the first wet season (approximately 70 consecutive days with moisture stress).

Climate has already been observed to change slightly in the county. Since 1981, the first wet season has experienced a very high (2.0°C) increase in mean temperature and associated reduction in crop cycle, and a fairly tendency for decreasing precipitation. The combination of increased temperatures and decreased precipitation make for an increase in drought risk in this first wet season. The second wet season experienced a mild (~0.5°C) increase in temperature, and slight tendency toward decreasing 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 (~0.5°C), with the first wet season projected to experience even greater changes. And by this time, precipitation is projected to decrease by 5% in the first wet season, and increase 14% 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 an increase in consecutive days with moisture stress, whereas the second wet season is projected to experience a slight decrease. Whereas, historically the second wet season experienced 20 days longer of consecutive moisture stress, however, in the future, the first wet season is projected to experience even longer periods of consecutive dry periods than the first (> 90 consecutive days of moisture stress). These projections of future climate change under the two climate scenarios—RCP 2.6 and RCP 8.5[17]—show very little difference indicating that these changes are projected to occur no matter the emission reductions that may occur in the future.

Climate from the farmers' perspective

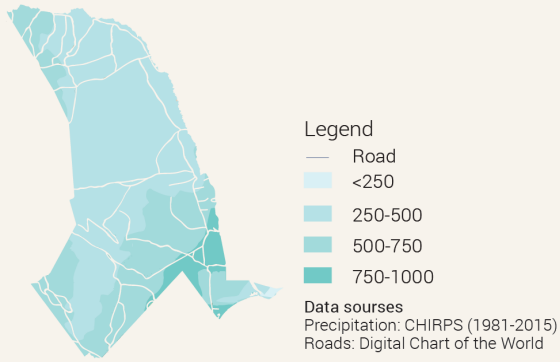
From the farmers' point of view, there has been a remarkable variation in the climatic conditions in Tana County over the years. They say the weather has become more unpredictable than in the past, mostly as a consequence of human activities. Data shows that the Lower Tana Basin experienced the highest deforestation rates of about 29% between 1990 and 2000, with only a 15% increase in forest as of 2010. Charcoal burning and promotion of afforestation are the main reasons for the decrease and increase in forest cover respectively. Similarly, a significant portion of about 6.7% of the grassland in the Tana Basin has been lost to cropland, and the recommended carrying capacity for livestock has been exceeded (Botzen et al., 2015).
Farmers report that the rains have not only decreased but have also changed patterns. For instance, they say the Long Rains, normally expected in April and May have been replaced in many years by dry spells. The Tana River floods, which used to benefit farmers, no longer coincide with the planting seasons. In addition, the River Tana has changed course over time. Farmers have seen the ox-bow lakes, such as Shakababo, Kongolola, Shungwaya, Muthanya and Shiloa, which were not only important for storing water but also as sources of fish, drying up. Frequent crop failures as a result of droughts or floods increase people's susceptibility to food insecurity and poverty. People along the coast report that the sea level has notably increased, causing fish migration towards the deeper seas. This then requires more sophisticated fishing material that are hardly available to local fishermen. There is a clear feeling that these changes make the crop farmers, fishermen and pastoralists more vulnerable. *Prosopis juliflora* (Mathenge) that was introduced in the county so as to increase the vegetative cover has colonized grasslands and replaced some grass species such as Sudan grass.

The significant change in temperatures, particularly manifested through warmer nights, have negatively impacted ecosystems. People report that some plants such as amaranth and animal species have disappeared from the county. Honey, for example, is no longer harvested from the wild as in the past, since bees have disappeared. Some of the new plant species like Solanum incanum are less palatable to livestock.

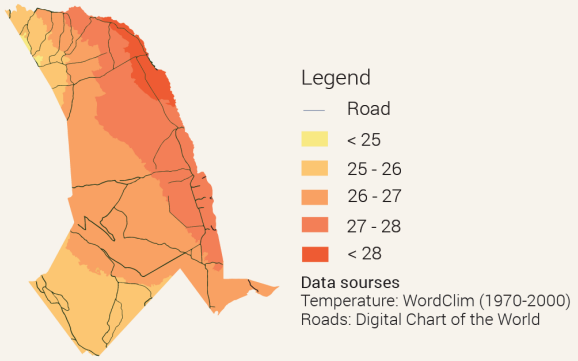
17 The two RCPs, RCP2.6 and RCP8.5, are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6 and +8.5 W/m2, respectively). The pathways are used for climate modelling and research. They describe two possible climate futures, considered possible 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 Tana River County

Historical annual mean precipitation (mm/year)



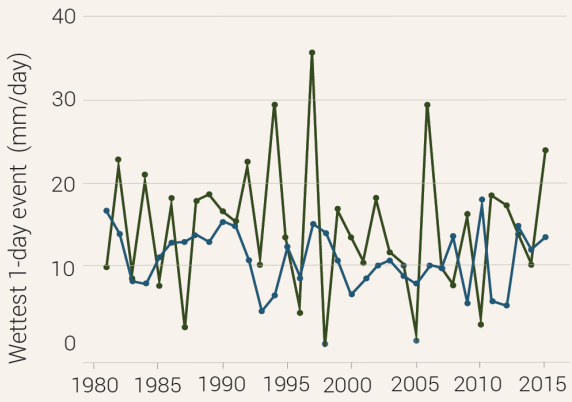
Historical annual mean temperature (°C)



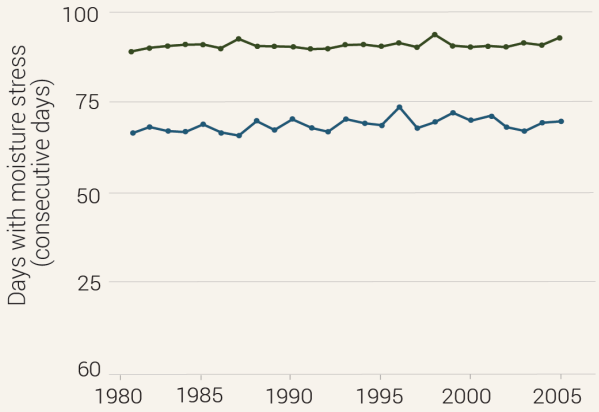
Flood hazards

Drought hazards

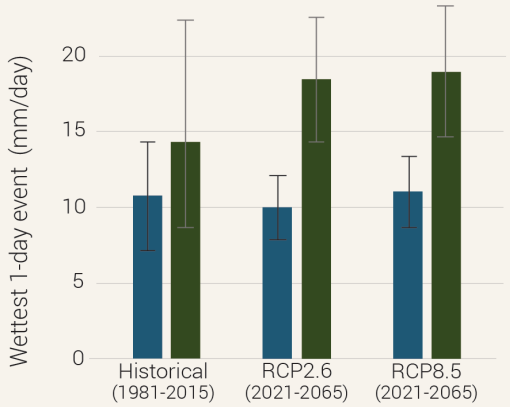
Historical extreme flood events



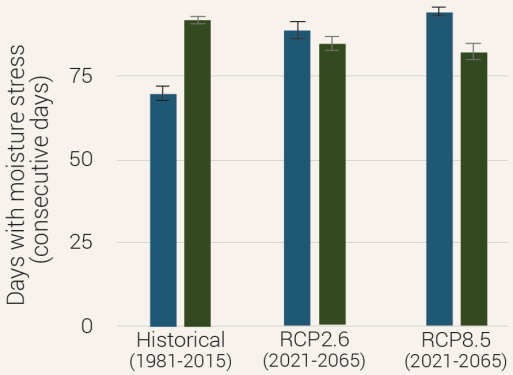
Historical drought stress events



Historical and expected extreme flood events



Historical and expected drought stress events



January - June July - December

Changes and variations in climate have posed important economic and social consequences. During extreme events such as floods and droughts, crop farmers experience crop failures, while pastoralists lose their livestock. Migration of livestock towards the Tana delta and also towards the neighbouring counties of Kitui, Kilifi and Garissa is common, and often results in conflict and loss of assets.

High temperatures are reported to have brought about increased incidences of pests and diseases such as the Rift Valley fever (RVF), ECF, and CCP in livestock, with areas such as Garsen, Assa, Nanighi and Kone being more affected. This factor has led to increased demand for pesticides and herbicides. Due to high evaporation rates, there is need for irrigation, which is low in the county. In addition, women must travel long distances in search of water due to water depletion in reservoirs, whereas men must spend more time migrating with livestock in search of pasture and water. In extreme cases in a drought year, "you have six people lining down [forming a human ladder] into a well to draw water", according to a district commissioner (Irinnews, 2011).

Due to low, unsustainable incomes from agriculture, women engage in other income-generating activities such as charcoal burning, whereas men must migrate to urban centres in search of employment. These changes have resulted in family disintegration and higher school dropout rates among children. Increased and uncontrolled charcoal burning has led to deforestation, worsening the impacts of climate variability. Susceptibility to diseases has been increased by the population's poor nutrition and scarcity of livestock blood during the dry season; livestock blood is considered a medicine in many households.

Climate vulnerabilities across agriculture value chain commodities

Expected future climate change and variation pose serious threats to the value chain commodities prioritized for analysis in this study. Hazards include drought, floods, erratic rainfall, increased temperatures, and pests and diseases. Drought and floods were identified as the most problematic hazards, both currently and in the future. These hazards affect the prioritized value chain commodities differently as in the following discussion.

Mango

Mango is a preferred crop in the dry areas due to its characteristic tolerance to harsh climatic conditions. Nevertheless, impacts of floods were identified as severe for all value chain stages namely input supply, on-farm production, and post-harvest and output markets, compared to drought where severity was identified as moderate and minor in the input supply stage.

In terms of production, over the years, it has been noted that the quantity of mangoes produced per tree, and the size of the fruits have decreased drastically due to prolonged and frequent droughts. Makenzi et al. (2013) observed that mango yields had a strong negative correlation with total precipitation in all the mango-growing areas such as Garsen and Kipini. Water scarcity causes low water uptake of newly planted mangoes and impairs flowering. Farmers opt to harvest mangoes before they reach maturity, to reduce the impact of hazards, a practice that reduces the future yielding capacity of the tree. Mangoes harvested prematurely are also smaller and more likely to go bad easily. This is one of the reasons why farmers get lower prices for their product on the market and have their livelihoods highly affected. This is despite the fact that there are markets for the unripe mangoes that can fetch higher prices for farmers. Poor market linkage in the county and lack of information are some of the factors impairing access to these markets.

Floods impact on–farm production, harvesting and marketing of mangoes mainly along the River Tana. Heavy precipitation causes rotting of mangoes, which then fall from the trees and impair access for harvesting and transportation to collection centre. However, it was noted that the impact of natural floods is less significant for mangoes in general, compared to artificial floods, caused by opening of the gates of dams upstream.

Maize

Prolonged and frequent droughts lead to maize crop failures particularly during October – February in the areas with no irrigation. For instance, maize was reported to have been damaged in these regions in 2016, due to the late onset of rain (FAO, 2016).

Drought imposes a number of challenges on the value chain. At the input supply stage, drought results in seed unavailability due to either low yields from the previous season, or farmers consuming everything during food scarcity periods, high fertiliser costs as well as inaccessibility to extension services as extension agents neglect the crop during dry spells. Maize grown during a dry spell is normally of poor quality due to impaired land preparation, poor germination and early ripening. These factors increase the susceptibility of the grains to storage pests such as weevils, a situation worsened by lack of good storage facilities.

Flood hazards on the other hand lead to deterioration of fertiliser quality and planting seeds as most of the seeds rot. This results in unavailability of and increased expenditure on inputs. Flooding along the River Tana also impairs transport following destruction of roads and storage facilities, contributing to poor access to extension services, production inputs (seeds, fertilisers), and market. A lot of water in the soil also makes land preparation difficult, requiring farmers to use more labour. Other challenges associated with floods include poor seed germination, on-field rotting of maize due to delayed harvesting, and hampered marketing. Moreover, cases of aflatoxins that severely affect maize production were reported to be more common during the floods season (March - September).

Green gram

Droughts cause wilting and flower abortion, significantly reducing green gram yields during the dry season (October – February). Moreover, the incidence of pests such as bruchids is higher during the dry spell. As a result, farmers who practice irrigation are required to use more pesticides, increasing the cost burden as well as environmental pollution. Since farmers may not always afford pesticides, pests develop resistance to the pesticides, making pest control difficult. The consequences are low production and poor quality of the product. Women are generally the group most affected by these consequences on green gram, since they are the main growers.

Floods also affect acquisition of important inputs such as pesticides, fertilisers, seeds, extension services, and access to markets, due to destruction of roads. Wastage of inputs (pesticides and fertilisers) is higher during flood seasons since most of the pesticides are washed off and fertilisers leached. In addition, activities such as weeding require more labour; farmers incur higher transport costs during this period. Farmers also face challenges harvesting and storing the crop. Green grams are more likely to sprout at this time in the field as well as during storage due to high moisture content. Lack of storage facilities and capacity to add value exacerbate the situation.

Goat (meat)

Drought causes both water and pasture scarcity, a scenario witnessed during the late onset of rains in 2016 (NDMA, 2016). As a result, livestock are poorly fed and forced to migrate in search of better conditions. This results in low livestock productivity, increasing numbers of weak and sick livestock and even death of livestock. Consequently, livestock keepers also need to spend more money and time on vaccination. When droughts become more frequent, the time for pastures and herds to recover from previous drought events decreases. Poor feeding, heat stress due to high temperatures, and increased movement result in reduced production of both meat and milk. Accessing markets at this period also becomes difficult, and the large numbers of goats with poor quality fetch low prices. Old, sick, and disabled people are most hit by these consequences, since their mobility is limited. Children are forced to drop out of school to move with the livestock.

Floods have been associated with an increase in infectious diseases such as RVF and CCP, which result in increased abortions and livestock mortality. Other diseases such as foot rot are also very common during floods. Farmers therefore spend more money on hoof trimming. The risk of losing livestock significantly increases especially during feeding and transportation. Demand for value-added goat meat products during this season limits market access for the pastoralists who lack the capacity to add value. Both these hazards translate to low farm incomes especially for the pastoral community and endangering of livelihoods. Poorer members of communities – those with smaller livestock holdings and less-developed social support networks are in general more affected by droughts and floods.

Adaptation to climate change and variability

In general, farmers' capacity to cope with and adapt to these changing conditions in climate has been impaired by the wider social and institutional context they live in. Due to human and livestock population growth, pressure on natural resources has increased. This, coupled with the loss of land and water resources to non-pastoral use and interruption of migration routes, leaves livestock keepers with fewer accessible feed and water resources. It also impairs their traditional ways of

coping with drought conditions. For livestock farmers these include fodder conservation, rearing improved breeds, vaccination of livestock before migration, and livestock insurance. For crop farmers these include improved seed varieties and inputs such as fertilisers and pesticides, which are costly or inefficient if they are not accompanied by proper training and knowledge on their application. Negative perception towards financial institutions makes farmers shun credit. Poor investments in infrastructure, including road networks and processing plants is obstructing their opportunity to access markets and add value to their products so that they can receive better prices and improve incomes. In addition, poor farmer organization limits collective production and marketing as a strategy for reducing transport costs and increasing bargaining power.

In spite of these challenges, farmers in Tana River have adopted various strategies to cope with climate hazards that affect agricultural production and food security. Results from the ASDSP survey of 2013 showed that at least 11% of the farmers have adopted several on-farm and off-farm adaptation strategies. At least 13% of male-headed households, 7% of both female- and youth-headed households have some adaptation to climate change (Annex 4). Male-headed households are more likely to apply climate change adaptation strategies on their farms. This is due not only to their higher access to productive resources, extension and training, but also to their higher decision-making power on household resource utilization, compared to women and youth. Some adaptations are specific to certain value chains whereas others cut across value chains.

On-farm adaptation options

Water harvesting is common to approximately 44% of the households mostly in AEZs CL3 and CL4, especially female-headed ones (GoK, 2014). The water, harvested from erratic rains which sometimes may result in flooding, is used for domestic and irrigation purposes. The strategy involves construction of water pans, shallow wells, desilting of the existing dams, and water tanks. Such initiatives are being supported mainly by development agencies such as the GAA, Samaritan's Purse, the KRC, the county government and sometimes farmer groups. Some challenges to adoption of water harvesting techniques include water scarcity and high poverty levels among the population, who do not have the means to invest in such a capital-intensive practice.

Soil and water conservation is also an important adaptation strategy in the county in AEZs CL3 and CL4, common in female-headed households (22%) compared to the youth- and male-headed households (7% and 4% respectively). High adoption of soil and water conservation measures among the female-headed households may be attributed to the fact that women are the ones who are responsible for fetching water, and more involved in crop farming compared to men who are more likely to move to other areas with livestock in search of water. Mulching is one of the soil and water conservation methods carried out in Tana River County. Farmers need to be trained on other methods of conservation agriculture such as minimum and zero tillage, a strategy that will address problems of weeding during flood seasons and land preparation during dry seasons. Currently, very little conservation agriculture is being practised in the county.

About 33 and 44% of the youth and female-headed households respectively have adopted drought-tolerant livestock types or breeds, as a climate adaptation strategy. For instance, goats are more preferred to other livestock types during the dry season since they can withstand harsh conditions. The major challenge with this strategy is that most pastoralists sell the livestock when they are already in poor body condition due to lack of feed and water. This means that the livestock fetch lower prices and are more likely to die if they don't find a buyer.

Crop farmers also opt for change in the crop types and varieties they cultivate as a response to increased extreme events. A good example is the farmers who, due to water scarcity, have replaced rice production with early-maturing and drought-resistant crops such as cowpea and green gram, mostly in AEZs CL3 and CL4. They also use high-yielding seeds that may be either purchased by the farmer or given by lead agencies in the county such as the crops department, Samaritan's Purse and German Agro Action. Youth-headed households are more likely to adopt the strategy compared to male- and female-headed households, given their increased interest in new technologies. A major impediment to using this strategy is poor access to improved seeds, given high prices, but also low productivity of the new crop types/varieties.

Tree planting and agroforestry are also practiced as adaptation and mitigation strategies, helping to conserve water and soil in AEZ CL3. Trees such as *Azadirachta indica* (Neem) and *Leucaena leucocephala* (also used for fodder) that are being

promoted in the county act as windbreaks, reducing wind soil erosion and increasing the vegetative cover that reduces water erosion as well as evaporation rates from the soil. The Kenya Forestry Service (KFS) is responsible for organizing tree planting in the county. Adoption of this strategy is closely linked to secure land tenure in the case of men and collective action in the case of women. It is also linked to availability of water, which is a general challenge in the county.

Value addition was also found to be a common adaptation strategy carried out by crop farmers and pastoralists in all AEZs. It helps increase the shelf life of agricultural products while enabling an increase in farmers´ bargaining power especially through activities such as bulking. Value addition also makes farmers get better prices compared to selling raw products. In the case of livestock farming, about 42, 33, and 30% of male-, female- and youth- headed households respectively add value to their products. This includes smoking, drying and frying and drying (referred to as "nyirinyiri"), boiling and fermentation of milk, de-feathering of chicken and drying and salting of fish. Value addition for crop production (and mostly in the mango and maize value chains) refers to sorting, grading, transporting, bulking and processing. These are mostly farmer group initiatives. The biggest challenge to value addition in the livestock and crop sector is lack of capacity in terms of knowhow, equipment, and resources. Potential adaptation strategies in value addition include upscaling of fruit packaging and processing through construction of a processing plant in the county, and reviving the collapsed ones such as the mango-processing plant.

In addressing the problem of unavailability of production inputs such as planting seeds, some farmers engage in production of the seed in home nurseries (mostly in AEZ CL3). Others buy the seeds from other sources, a strategy that is not always viable due to high prices given the high poverty levels in the county. Seed subsidization by the government and other organizations such as Samaritan's Purse is also not adequate, as distribution is hindered by the poor road network. It was recommended that options such as establishment of community nurseries should be pursued. Instead of fertilisers, which are also expensive and unavailable most of the time, farmers use manure. This strategy does not sufficiently meet the crop requirements, hence the need to train farmers on composting and practices such as organic farming. Similarly, extension services from extension agents have been replaced by indigenous knowledge. Farmers are therefore rarely aware of new production methods. Strategies such as use of mass media should be explored in future to facilitate extension.

Mass vaccination of livestock is another important adaptation strategy for the livestock sector. It is common in the pastoral regions namely CL4, CL5, CL6 in view of the many livestock disease outbreaks particularly during the dry season; the situation is worsened by migration of livestock from neighboring counties such as Kitui and Garissa. In 2016, about 500,000 cattle were vaccinated against RVF (NDMA, 2016). This measure helps reduce the likelihood of livestock contracting diseases as they move. During flood seasons, hoof trimming is the most common adaptation strategy for reducing impacts of diseases such as foot rot in goats. In spite of the adaptive measures, there is need to strengthen disease surveillance in the county as well as establish disease-free zones. This needs to be accompanied with regulation of livestock movement from the neighbouring counties.

Rehabilitation of grasslands through reseeding, production of pastures under irrigation and fodder conservation are the on-going adaptation strategies to the problem of feed shortage common during the dry season. The strategies are applied mostly in AEZs CL4, CL5, and CL6. Fodder conservation was found to be common in female-headed households (33%) compared to the male- and youth-headed households (16% and 22% respectively) according to the ASDSP survey of 2013. Women are more likely to adopt fodder conservation given that they never migrate with livestock as frequently as men. Fodder and feed conservation is supported by organizations such as the United Nations (UN) under the United Nations Development Programme (UNDP). This undertaking needs to be up-scaled to cover all the areas in the county.

The challenge of poor access to markets has not been addressed satisfactorily by the on-going adaptation strategies such as selling individually, value addition (given that it is minimal) and premature harvesting. These strategies can be complemented with options such as collective selling, training farmers and providing the required resources for value addition, and engaging farmers in contract farming. Encouraging farmers to organize themselves into groups can also help in reducing the cost incurred in transportation.

Off-farm services

Off-farm services such as early warning systems, insurance schemes, extension and training, credit, storage facilities, and market information are offered to farmers in Tana River County to increase their climate adaptive capacity. Such services are offered by a variety of stakeholders from local government (such as the meteorological, veterinary, agriculture, fisheries, and livestock departments) to organizations like GAA, KRC, and NDMA.

Early-warning systems enable farmers to know when and where to plant, and when to move with the livestock, based on information on occurrence of drought and floods. Access to this information is facilitated by the NDMA and other organizations such as the KRC and the KMD; it reaches farmers by means of radios, workshops, and trainings organized by the above-mentioned organizations. However, there is no meteorological station in Tana River County so the information is transmitted from the neighbouring county of Garissa. This may compromise information precision sometimes, especially in view of the high weather variability which is hard to predict with the existing technology.

A challenge to the Early-warning system is that most of the time farmers neglect the information. For instance, it was reported that farmers never comply with alerts encouraging them to move away from the river banks to avoid floods. The negligence is as a result of non-occurrence of previously predicted weather events, and cultural inclinations. The Pokomo people, for example, like staying close to rivers so they never give heed to alerts to move away from rivers to avoid floods. Also, utilization of print media to disseminate Early-warning information limits the number of farmers who may be reached owing to the high illiteracy levels.

Extension services are provided by the government and other organizations such as Samaritan's Purse, GAA, and KRC. Extension involves field visits, focus group discussions, and workshops on aspects related to the entire value chain. These include: crop planting and growing times, input utilization and value addition, and amount of product to sell on the market. Extension training includes fodder conservation (Kidake et al., 2016), post-harvest handling, proper storage, beekeeping (through the Kenya Agricultural Productivity Programme [KAPP]) and marketing. In the livestock sector, farmers have been trained on the importance of destocking and feed storage, which helps increase production. Nevertheless, it was reported that the number of farm visits by agricultural officers has been significantly reduced in the past years due to low budgetary allocation and poor road network in the county. In addition, farmers are reluctant to adopt new technologies due to sociocultural factors such as reluctance to diversify into crop production by the pastoral community, and lack of evidence of impact of these technologies on production and incomes (through, for instance demonstration plots).

Despite existence of financial institutions such as banks in the County, access to financial credit (loans and insurance) is very low according to the ASDSP survey of 2013. The situation persists since most of the financial institutions shy away from the Arid and Semi-Arid Lands (ASALs) given the high production risks. Lack of awareness about credit services (from the side of the farmers and pastoralists alike) is also a contributing factor. This is expected to change following some initiatives such as the Kenya Livestock Insurance Programme (KLIP).

Storage services are limited to fodder, where the LPD under the MoLAI stores fodder for farmers under the feed production programme. Delivery of storage services requires upgrading to all agricultural commodities such as cereals, mangoes, and even dairy. This also applies to market information services that are mainly offered by the MoLAI andd TechnoServe. The latter links mango farmers to buyers. Access to these services is very low, particularly for female-headed households (0%) compared to male- and youth-headed households (3 and 7% respectively) (GoK, 2014a).

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

Mango

	Provision of seeds and other inputs	On-Farm production	Harvesting storage and processing	Product marketing
Floods	Hinder access to nursery inputs; poor seedling establishment in water logged soils	Heavy rains causing floods result to: loss of tree flowers, pest incidences, disease damage and fruit bursts at fruiting stage; loss of fertiliser and pesticides through run-off and leaching	Hinder access to orchard fields; low fruit quality from damages incurred at harvest and damaged storage structures	Damage to existing roads hinder fruit transportation to markets and increase transport costs; low fruit quality lower fruit purchase costs.
Magnitude of impact	Severe	Severe	Severe	Severe
Farmers' current strategies to cope with the risks	Farmers establish nurseries outside flood-prone areas; source seedlings from outside suppliers	Stopped application of fertilisers and pesticides; on-farm diversification; seeking alternative means of livelihood	Fruit sorting/grading	Maximise fruit harvests; Rapid transportation to market outlets; maximise price negotiations within existing informal market standards
Other potential options to increase farmers' adaptive capacity	Community nurseries; Promote grafting	Drainage canals	Increased household capacity to assess fruit quality (size, form, color); improve storage structures	Use of refrigerated trucks to transport ripe mangoes to the market; establishment of niche, specialty markets for non-ripe mangoes.
Droughts	Reduce use of high quality soil fertility inputs such as farm yard manure	Temperature extremes reduce: seedling growth rates; quality and quantity of tree fruit production; susceptibility to pest and diseases	Prolonged fruit harvesting, reducing quality and quantity of harvested fruit	Reduce quality of harvested fruit reduces: limiting shelf life, decreasing product prices and opportunities for value addition
Magnitude of impact	Minor	Severe	Severe	Severe
Farmers' current strategies to cope with the risks	Home seed nurseries: either tree or vegetable nurseries whether at home or commercial established with minimal farm inputs (fertilisers and pesticides)	Pruning at the wrong time of year/seasonal cycle; Agroforestry; water harvesting; tree planting; on-farm diversification; alternative means of livelihood	Sun dry of harvested fruit, either under trees or in storage sheds; minimal value addition to the product (juice making)	Marketing of fruit on niche markets (for juice)
Other potential options to increase farmers' adaptive capacity	Construction of water conservation structures such as Zai pits and irrigation facilities	Pruning at the right duration within the seasonal cycle; use of Intergrated pest management techniques	Low-temperature storage facilities; mango processing (e.g domestic or commercial drying)	Creation/ strengthening of cooperatives to add value to products and of alternative niche markets (for non-ripe mango)

Maize

	Provision of seeds and other inputs	On-Farm production	Harvesting storage and processing	Product marketing
Floods	wash away soil, leaving seeds uncovered; hinder access to planting inputs (ferilizers and pesticides)	Delay land preparation and planting (after flood recession); increased incidence of seed and seedling rotting	Reduce (rotting and aflatoxin) of harvested and stored seed produce	Limit access to produce markets due to damaged roads and high costs for riverine transportation
Magnitude of impact	Severe	Severe	Moderate	Severe
Farmers' current strategies to cope with the risks	Farmers rely on distributed seed and subsidized fertilisers from the goverment and releif/aid agencies	Early crop and biomass harvesting; on-farm diversification; seek alternative means of livelihood (e.g employement)	Repairs and maintenance to damage storage structures	Produce hoarding to force price increases; divertion of market produce for household consumption
Other potential options to increase farmers' adaptive capacity	Establish drainage structures (trenches); replicate existing irrigation schemes (such as Bura and Hola schemes)	Building dykes; Land drainage; provision and utilization of early maturing varieties	Storage structures established on higher grounds, using water-proof materials	Collective marketing (using farmer cooperatives); value addition to diversified consumer products
Droughts	Limit availability and access to inputs (seeds and fertilisers); increase input prices	Delay land preparation and planting and escalate costs; increase pest and disease incidence; reduce optimal crop growth	Contribute to premature crop harvesting; increase likelihood of storage pests; increase processing costs (for mills repair) due to processing of premature seeds	Increase market costs, due to scarcity of product
Magnitude of impact	Severe-Moderate	Severe	Moderate	Moderate
Farmers' current strategies to cope with the risks	Farmers rely on distributed seed and subsidized fertilisers from the goverment and releif/aid agencies	Early harvest of crop biomass, Agroforesty; soil water conservation techiques; cover crops; water harvesting; tree planting; on-farm diversification; alternative means of livelihood	Repair damaged storage structures resulting from high temperatures; reparations and mainteance of storage structures	County goverments buying produce from farmers
Other potential options to increase farmers' adaptive capacity	Alternative seed bulking sites (such as Hola and Bura); capacity building on soil fertility management (such as compositing); fertiliser plant	Conservation agriculture; Irrigation facilities (small and large scale)	Establishment of storage structures away from ground level; use water-proof construct material for storage structures; diversification of means of transporations; eestablishment of processing plants capable of processing seed from many crop commodities	Tapping into organized markets and seeking new marketing opportunities outside the county

Green gram

	Provision of seeds and other inputs 	On-Farm production 	Harvesting storage and processing 	Product marketing 
Floods	Limit availability of of planting seed; increase costs of pesticides	Delay land preparation and planting; increased agronomic labour costs (planting, weeding); seed and seedling losses from water logging and rotting	Increase incidence of rotting and germination of harvested seed	Limit access to market due to bad roads; increase transportation costs; reduce prices for poor quality seed
Magnitude of impact	Major	Moderate-Severe	Major	Major
Farmers' current strategies to cope with the risks	Rely on seeds from government and releif/aid agencies	Early seed and biomass harvesting; agroforesty; soil water conservation techiques; cover crops; on-farm diversification	Utilization of household (jerricans/gunny bags) resources as storage material; repair and reinformcement of food storage facilities	Harvested produce majorly consumed at household level
Other potential options to increase farmers' adaptive capacity	Seed and pesticide subsidies; community seed stores	Drainage structures	Improved grain storage facilities	Farmer groups to facilitate shared transportation: transportation costs, marketing and value addition to new products
Droughts	Lead to scarcity of planting inputs (seeds and fertilisers) and high pesticide costs	Increase labour costs and contribute to crop wilting and flower abortions	Increas risk of infestation by storage pests (such as weevils and bruchids); low diminish quantity and quality of harvested seeds	Contribute to loss produce markets
Magnitude of impact	Major-Moderate	Major-Severe	Major	Major
Farmers' current strategies to cope with the risks	Reliance on farm inputs (seed/fertilisers/pesticides) distributed by county goverment and NGO's	Use of traditional farm tools (such as hoes), tractors and ox plough to offest labour costs; crop change to early maturing varieties; staggered cropping; water harvesting; tree planting; on-farm diversification (agro-forestry)	Utilization of household (jerricans/gunny bags) resources as storage material	Sale of produce at farm gate price
Other potential options to increase farmers' adaptive capacity	Farmers' trainings on seed bulking strategies	Intercropping with cereal and root crops such as maize and cassava rotational cropping; trainings on Integrated Pest Management (IPM)	Improved seed storage structures; use of proper storage equipment (sisal gunny bags); use of silos	Contract farming opportunities

Goat (meat)

	Provision of inputs	On-Farm production	Harvesting storage and processing	Product marketing
Floods	Reduce quality and quantity of pastures; prevent extension agents'and vets'access to the farms due to flooded roads, limiting coverage of extension services	Increas risk for livestock pest and diseases; cause natural loss (through drowning, starvation); increas husbandry costs (such as hoof trimming)	Increase mortality risk during transporation to external markets (through drowning)	Shift focus from identifying markets and value addition opportunities
Magnitude of impact	Moderate-Major	Moderate-Major	Uknown	Major
Farmers' current strategies to cope with the risks	Rangeland reseeding to improve pasture germination	Destocking of old and weak goats; use of indigenous knowledge to treat animal diseases; animal migration to other communal pasture lands; seek alternative means of livelihood (e.g employement)	Sale of goats at within the community; Slaughter for household consumption	Participation in animal off take programs; meat sale to local markets
Other potential options to increase farmers' adaptive capacity	Flood mitigation strategies; improved technologies for pasture production (tumbukiza); community protected pasture lands	Disease tolerant and climate-adapted goat breeds	Abbatoirs at accessible points; capacity building on meat grading and value addition	
Droughts	Poor pasture establishment; lower pasture quality and establishment	Contribute to stunted growth and susceptibility to pest and diseases	Increase risk mortality (e.g transporation to outside market) reduces market purchase costs; Poor quality increases meat processing costs	Lead to low goat prices due to market oversupply and low quality of meat
Magnitude of impact	Severe	Major-Severe	Major-Severe	Moderate -Major
Farmers' current strategies to cope with the risks	Migration of livestock to other pasture lands; tree planting and agroforesty species	Destocking; use of indigenous knowledge to treat animal diseases; animal migration to other communal pasture lands; adoption of drought torelant livestock breeds; seek alternative means of livelihood (e.g employement)	Culling of old and weak goats; feed conservation (fodder, balers, improved storage facilities)	Value addition through alternative meat products (such as "nyiri nyiri"); slaughter for household and local consumption
Other potential options to increase farmers' adaptive capacity	Communal pasture lands along water bodies (such as river Tana)	Creation of disease-free zones; research for newly emerging diseases introduction of new superior breeds	Abbatoirs at accessible points; community based cold storage facilities (refrigiration)	New markets opportunities outside the county; contract marketing; access credits from financial institutions; linkage to market information services

Policies and programmes

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

The Adaptation to Climate Change in Arid and Semi-Arid Lands (KACCAL) Programme, developed by the WB and the MoALF in 2010 seeks to improve the ability of ASALs to plan and implement climate change adaptation measures through capacity building, implementing climate-smart interventions and increasing access to climate-related knowledge. In Tana River County, the programme has promoted value addition activities for instance in the mango value chain, through activities such as construction of mango collection centres. About 11 mango farmer groups have benefitted from grants that were provided by the programme to finance various micro-projects. The programme also promotes management of floods and droughts through construction of water pans. Farmers reported having received training on climate change under the auspices of the programme.

The Agricultural Sector Development Support Programme (ASDSP), developed by the Kenyan and Swedish governments in 2010 has been targeting increasing agricultural production and productivity in rural households through capacity building. The programme has promoted Participatory Scenario Planning, where beneficiaries (farmers) of a certain intervention are given the chance to identify the most pertinent interventions as well as the most effective implementation strategies. Access to extension services which include knowledge sharing and transfer on crop selection, use of improved seeds and early maturing varieties has been promoted through development of linkages between farmers and relevant stakeholders in the agricultural sector such as research organizations and input dealers.

With regard to crop farming, the Agriculture (Farm Forestry) Rules enacted under the Agriculture Act in 2009 encourage farmers to maintain a 10% tree cover to improve soil and water conservation (GoK, 2009). Other than issuance of a compliance certificate to farmers who attain this target, there are no monetary incentives to encourage farmers to strive towards achieving the goal. Compensation for any damaged trees is not efficient since damage is assessed after five years. This period is too long to allow capturing of the real value of damage experienced. Considering the role perennial crops such as mangoes and bananas play in increasing vegetative cover, the policy has not increased production of these crops. It was reported that farmers were cutting down their mango trees due to low mango prices in the market. The policy needs to be customized for the county, considering that it was formulated at the national level.

Scarcity of water for livestock, conflicts over land resources, and disease outbreaks are some of the major challenges that require visibility on the livestock public policy agenda in Tana River County.

The Kenya Livestock Insurance Programme (KLIP) developed in 2015 and launched in 2016 by the national government aims at covering livestock farmers in ASAL counties during droughts. In Tana River County, the programme is anticipated to benefit about 2,500 households (constituting 5% of the total households in the county), by cushioning them against feed shortages. Recruitment of beneficiaries is ongoing and the first payments will be made in 2017 March depending on whether there will be significant failure of pastures to regenerate due to drought. The programme covers only five livestock units where the government pays 2,000 KES for each livestock unit while the insurance company pays 14,000 KES, making a total of 80,000 KES. This is a pilot project that seeks to increase pastoral resilience to drought through enabling the pastoralists to buy feeds or migrate to areas with pastures. The negative perception about financial institutions (that they take advantage of the ignorance and vulnerability of the farmers) by the local people and the reluctance to destock in the event of climate-related disasters are some of the factors that might deter realization of the policy's objectives.

The County government, through the MoALF, and in collaboration with the Food and Agriculture Organization (FAO) of the UN, has been working towards increasing availability of pastures in the county. This is a strategy to diminish impacts from climate hazards on livestock production and to reduce pastoralist migration that puts further pressure on the environment. Known as the Drought Mitigation on Livestock through Feed Production, the programme started in 2014 and promotes hay production and storage during the wet season for use in the dry season. It has so far managed to plant about 87 acres of land with Sudan grass and the African Horse Tail, and constructed storage facilities in Hola. Selling hay is becoming an important source of income as a 15-kg bale can fetch up to 300 KES. However, farmers have reported shortages of water for irrigation, which compromises availability and quality of pastures. This is a major drawback on pasture production.

To tackle human-wildlife conflicts which are most common during dry spells as wild animals break into farms to look for pastures and human beings encroach on protected areas, the Wildlife Conservation and Management Act (WCMA) developed in 2013 has been established to compensate any personal injury or destruction of property (livestock and crops) caused by wildlife (GoK, 2013b). However, inadequate wildlife monitoring mechanisms have compromised the effectiveness of this policy, since most of the compensation claims remain unpaid. In addition, the county is currently preparing a Grazing Bill, which seeks to have grazing land clearly demarcated. This would contribute to reduction of human-wildlife conflicts as well as intercommunal conflicts which are normally triggered by wrangles over natural resources such as pasture lands. However, the bill does not take into account the absence of a clear land tenure system in the county, which can be a major impediment for effective operationalization of the law if the bill is passed.

Unwritten rules play an important role in the way resources are allocated and managed by households and the community. Interestingly, sometimes these informal rules, set by the local administration and the residents, go against traditional and cultural beliefs. For example, crop farmers are expected to avoid planting close to the river banks, in order to prevent soil erosion and decrease the crops´ exposure to floods. However, farmers (the Pokomo) in Tana River County have lived and farmed in the proximity of rivers for years. In the absence of alternative livelihood opportunities and institutionalized, effective rules, changing farming behaviour will continue to be a challenge. The unwritten rules are more effectively implemented and adhered to, compared to the written rules, mostly known by the few elites. This is because the former have been well understood and owned, making them part and parcel of day-to-day living.

In the case of livestock, destocking is one of the ways of promoting sustainable use of land and water and reducing environmental degradation. Pastoralists are encouraged by various organizations such as Samaritan's Purse and the Ministry of Agriculture, Livestock and Fisheries to keep few high-yielding livestock on the farm, selling the remaining ones early enough during the dry season, before their body condition becomes wasted. However, culturally, in Tana River County, as in many parts of Kenya, ownership of livestock denotes social status and prestige. Without knowing the implications of such measures and the benefits of destocking, pastoralists will continue to put further pressure on resources, exposing them to the effects of climate hazards even more, and ultimately lose their livelihoods.

An integrated approach to farming and human health has been evident through the regulation that restricts access to and movement of livestock in public areas such as schools. The aim is to decrease the likelihood of disease outbreaks such as RVF and Anthrax normally contracted from animals. In order to be granted permits for moving their livestock, farmers need to vaccinate them. Vaccination services are offered by the county government through the veterinary department under the MoALF at subsidized rates. However, pastoralists move with their livestock, sometimes at night, making vaccination and regulation of livestock migrations difficult. Inadequacy of finances to enable the veterinary department to purchase the vaccines also reduces accessibility to the veterinary services.

There are major bottlenecks regarding the enforcement of the above-mentioned policies, programmes and even unwritten rules. Some of the challenges are due to lack of awareness about the policies, programmes and norms, and to the vastness of the county, which requires a bigger task force to implement and enforce the policies. Despite the county government dispensation, most counties, Tana River County included, still run on policies that were designed at national level. Such policies include the Agriculture (Farm Forestry) rules and the WCMA (Ng'endo et al., 2013). Cultural inclinations such as the strong attachment to livestock for the pastoralists, non-sedentary lives, and low literacy levels pose major hindrances to effective enforcement of some of the policies. In addition, frequent monitoring and evaluation of the programmes/interventions become a challenge given the vastness of the region, a factor that is likely to reduce success rates of interventions.

Governance and institutional resources and capacity

There are various governmental, non-governmental (NGOs), community-based, faith-based and private organizations in the county that directly or indirectly deal with climate risks.

County-level government institutions include local offices of the MoALF, the KMD, the KFS, the Ministry of Water and Irrigation (MoWI), the National Environmental Management Authority (NEMA), the Kenya Wildlife

Service (KWS) and the NDMA. These departments and agencies provide agricultural extension, inputs and policy support. Specific interventions include construction of water facilities such as boreholes and water pans by the water department, vaccinations by the veterinary department, promotion of pastures by the agriculture department, and destocking by the livestock department. Tree planting and controlled bush clearing are being promoted by KFS, regulation of livestock movement by KWS, regulation and coordination of various environmental projects by NEMA and policy support by ASDSP. The NDMA is the only organization that directly deals with climate change risks, providing early warning information to farmers in collaboration with KMD.

Key international organizations working in the county in areas related to provision of water tanks, agricultural inputs like fertilisers and pesticides, greenhouses and extension on good agricultural practices include GAA, KRC, the World Food Programme (WFP) and FAO.

Faith-based organizations such as Samaritan's Purse and the Catholic Relief Services (CRS) focus mainly on emergency response, engaging in activities such as conflict resolution, rescue services, administration of food aid, and disasters. The two organizations also have a development component, providing extension, inputs such as fertilisers, high-yielding seeds and irrigation equipment to farmers. They also link farmers to markets by encouraging them to organize themselves into groups so as to strengthen their bargaining power.

Community-based organizations include Tana Peace, whereas private organizations include Technoserve and Team and Team. Team and Team is actively involved in construction of water pans and water tanks. Tana Peace was formed to reduce conflicts in the county whereas Technoserve offers extension services on input utilization as well as buying produce such as mangoes from the farmers.

Coordination among these organizations exists at some stages of intervention design and implementation. Collaboration was reported to exist within the government departments. However, other than for a few cases, NGO to NGO collaboration and NGO to government department collaboration were minimal if any existed. This may be due to the fact that most of these NGOs are autonomous in operation. Local people/beneficiaries are consulted on topics related to land tenure regimes and the general acceptability of the intervention in the planning phase, yet their engagement in subsequent steps is limited, according to reports.

Several factors impair success of climate risk interventions in the county. The major hindrance is lack of timely and sufficient funding. Insufficient funds contribute to inadequate human capacity in terms of knowhow and number of staff in almost all the government departments and other organizations. Out of the ten key informants that were interviewed (representing government departments, NGOs, Private and faith-based organizations), five had not received any form of training on climate change risk management. This is exacerbated by the fact that multi-stakeholder fora on climate change are no longer being held. There is no legislation on climate change for Tana River County that describes who, and how to enforce policies for climate change in addition to lack of a climate change policy. These factors reduce the degree of coordination and collaboration.

Synthesis and Outlook

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

Significant initiatives to increase resilience in the agricultural sector have been evident in Tana River County. These include on-farm practices that target water and soil conservation and management, such as water pans, shallow wells, desilting of existing dams and water tanks, mulching, crop rotation, agroforestry systems, and drought-resilient livestock breeds. In addition, off-farm services and programmes have been provided to act as enablers for uptake of adaptation options. Such services and programmes include provision of early warning systems, extension services, and technical support (building of small-scale irrigation pumps).

While it is important to continue implementing such initiatives and supporting them through actionable policies and strategies, integrated agricultural development requires adaptation measures that target the entire value chain activities. On-farm production is important; however, without ensuring enabling conditions for provision of and access to inputs such as seeds, fertilisers, pesticides, product storage, and market access, farmers' livelihoods and incomes remain at risk. This is because climate hazards are expected to affect all important value chain activities. Distribution of the inputs, mainly seeds and fertilisers, should be timely and synchronized with rain cycles.

This will address claims by farmers that the inputs are never available during the onset of rains. This can be achieved through construction of more input outlets and collaboration with the KMD. Also of particular importance 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, for instance, fruit juice, smoked and/or dried meat, and processed milk can open up new niche markets for farmers.

Apart from these measures, 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 (fertilisers, 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 the assessment of local needs and resources could represent an important step towards the operationalization of the country's climate strategy.

Furthermore, increased alignment of public and private funds aimed 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, which currently lack resources to effectively deliver services (climate information, extension, veterinary support and subsidies). Promotion of collective action groups can further strengthen the existing local norms such as communal land ownership (for activities like community seed nurseries).

Furthermore, in order to improve the quality of weather data and to strengthen early-warning systems, the installation of real-time automatic meteorological station, specific for utilization by County stakeholders, should become a priority. Venturing into mass media (for instance, radio ITC) for offering extension services could be an additional option for information dissemination.

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

Annex 1: Administrative division of Tana River County
Annex 2: Selection of Value Chain Commodities in Tana River
Annex 3: Crop productivity by gender
Annex 4: Climate analysis
Annex 5: Selection of adaptation options in Tana River County

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