Climate Risk Profile
Mandera County

Highlights

- Mandera County is predominantly semi-arid, with most of the county receiving average annual rainfall of below 250 mm. Despite the unfavourable climatic conditions, agriculture is the major livelihood in the county, employing over 90% of the population. Livestock production is the predominant sub-sector, employing over 84% of the population, and contributing approximately 72% to household incomes.

- The county is highly vulnerable to droughts, heat stress and moisture stress, hazards that affect the production, storage and sales of agricultural produce and livestock products. Flash floods also occur periodically, affecting both crop and livestock production including limiting access to inputs and markets for the sale of produce.

- Analysis of historical trends over a 30-35 year period shows that temperatures have been increasing and rainfall decreasing, while climate projections for the period 2021 to 2065 indicate that these trends are expected to continue and the County will remain highly susceptible to droughts and floods.

- Current coping mechanisms for droughts and floods include planting drought-tolerant crop varieties, establishing small-scale water harvesting, in-field soil and water conservation structures, water trucking, destocking, fodder production and conservation, small-scale irrigation, and tree planting/ agro-forestry. However, the uptake and adoption of these practices is challenged by lack of financial resources and technical skills.

- Longer term adaptation strategies with potential to alleviate the impacts of droughts and floods on crops and livestock include dam construction and expansion of irrigation infrastructure, improved grazing land management, and construction of modern storage, processing and sales facilities. Continued capacity building of farmers and establishment of cooperatives remains a key area of work.

- Off-farm services available to pastoralists and agro-pastoralists to increase their adaptive capacity include; weather forecasts which include long and short rains assessments, livestock insurance schemes and formation of farmer/pastoralist groups/ cooperatives for easy access to loans, inputs as well as improved bargaining power for better prices for their products and inputs.

- The adaptive capacity of the county's population is hampered by high poverty and illiteracy rates, adverse climatic conditions, poor road infrastructure, and outbreaks of livestock diseases, environmental degradation and insecurity.

- Involvement of actors such as National Drought Management Authority (NDMA), the Agency for Technical Cooperation and Development (ACTED), World Food Programme (WFP) and faith-based organizations such as Islamic Relief through a stakeholder's forum led by the County Steering Group continues to be a key pillar of resilience in the community. However, there is a need to strengthen collaboration among stakeholders for optimal use of resources, reduction of duplication and ultimately more efficient and effective response to the hazards in the County.

- Despite efforts to increase resilience to climate change, lack of and/or weak county-specific policies, and inadequate mechanisms and capacity to coordinate, implement and monitor interventions present important institutional barriers to effective climate risk management in the county.

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

List of acronyms

ACT	Africa Conservation Tillage
ACTED	Agency for Technical Cooperation and Development
AEZ	Agro-ecological zone
ASAL	Arid and Semi-Arid Lands
ASDSP	Agricultural Sector Development Support Programme
CERF	Central Emergency Response Fund
CIDP	County Integrated Development Plan
COCOP	Consortium of Cooperating Partners
CSG	County Steering Group
DFID	Department for International Development
EC	European Commission
EWS	Early Warning System
FAO	Food and Agricultural Organization of the United Nations
FHH	Female-headed households
GHG	Green House Gases
GLSA	Group Savings and Loans Associations
GoK	Government of Kenya
HDI	Human Development Index
HNSP	Hunger Safety Net Programme
ICPAC	IGAD Climate Prediction and Application Centre
ICPALD IGAD	Centre for Pastoral Areas and Livestock Development
IDA	International Development Agency
ILRI	International Livestock Research Institute
IGAD	Intergovernmental Authority on Development
KALRO	Kenya Agricultural and Livestock Research Organization
KAPP	Kenya Agricultural Productivity Program
KCSAP	Kenya Climate Smart Agriculture Project
KDLDP	Kenya Drylands Livestock Development Program
KES	Kenya Shillings
KFS	Kenya Forest Service
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KLIP	Kenya Livestock Insurance Program
KMD	Kenya Meteorological Department
KPHC	Kenya Population and Housing Census
KRC	Kenya Red Cross
LM	Lower Midland
MHH	Male-headed households
MoALF	Ministry of Agriculture, Livestock and Fisheries
NAPAD	Nomadic Assistance for Peace and Development
NCCAP	National Climate Change Action Plan
NCCRS	National Climate Change Response Strategy
NDMA	National Drought Management Authority
NEMA	National Environmental Management Authority
NGO	Non-governmental Organization
RACIDA	Rural Agency for Community Development and Assistance
RPLRP	Regional Pastoral Livelihoods Resilience Project
SADC	Swiss Agency for Development Corporation
TIMPs	Technologies Innovations and Management Practises
TLU	Tropical Livestock Units
WFP	World Food Programme
VCC	Value Chain Commodity

Foreword

Climate change is becoming one of the most serious challenges to Kenya's achievement of its development goals as described under Vision 2030. Kenya is already highly susceptible to climate-related hazards, and in many areas, extreme events and variability of weather are now the norm; rainfall is irregular and unpredictable; while droughts have become more frequent during the long rainy season and severe floods during the short rains. The arid and semi-arid areas are particularly hard hit by these climate hazards, thereby putting the lives and livelihoods of millions of households at risk.
In 2010, Kenya developed a National Climate Change Response Strategy (NCCRS), which recognized the importance of climate change impacts on the country's development. This was followed by the National Climate Change Action Plan (NCCAP) in 2012, which provided a means for implementation of the NCCRS, highlighting a number of agricultural adaptation priorities. The focus of these initiatives has been at the national level, there is need to mainstream climate change into county level policies, programmes, and development plans; therefore ensuring locally relevant, integrated adaptation responses with active involvement of local stakeholders.

The Government of Kenya (GoK) through the Ministry of Agriculture, Livestock and Fisheries (MALF), with funding by the International Development Agency (IDA-World Bank Group) is therefore implementing the Kenya Climate-Smart Agriculture Project (KCSAP). This projects objective is to increase agricultural productivity and build resilience to climate change risks in targeted smallholder farming and pastoral communities in Kenya, and in the event of an eligible crisis or emergency, to provide immediate and effective response. This Climate Risk Profile has been conducted within the framework of KCSAP and aims to inform county governments and stakeholders on the climate change risks and opportunities for agriculture so they are able to integrate these perspectives into county development.

This document presents the Climate Risk Profile for Mandera County with a climate change vulnerability index of 0.369[1]. The county is characterized by very high poverty levels (89%) and food insecurity, with for instance 36% of children below the age of 5 being stunted, and a high dependence on food relief for both humans and livestock[2]. These are largely attributed to the harsh climate and historical insecurity in the county. Assessment of historical climate data reveal a reduction in the drought cycles, from 10 years to every 2-3 years[3], where every dry season is followed by a period of above normal rains. In the event of a drought, depending on the severity, pastoralists lose at least 40% of their livestock[4]. For instance during the 2011 drought, pastoralists lost approximately 65% of their herds[5]. The droughts also result in severe crop failures which have resulted in a remarkable decline in the cropped area[6]. In equal measure, floods are detrimental in the county, for example the floods of 2008 submerged approximately 600 hectares of cropland affecting the livelihoods of about 1200 households in Rhamu division[7]. The fragile socio-economic and environmental setup has attracted a number of government and non-government organizations' interventions in the county aimed at building resilience and improving the adaptive capacity of the residents. Such interventions include food programmes such as the Hunger Safety Net Programme (HNSP) and the Kenya Livestock Insurance Programme (KLIP). Nevertheless, greater impacts could be realized if interventions addressing the current underlying vulnerabilities, institutional gaps in terms of capacity, and policy are put in place.

The profile is organised into six sections, each reflecting an essential analytical step in understanding current and potential adaptation options in key local agricultural value chain commodities. The document first offers an overview of the county's main agricultural commodities key for food security and livelihoods as well as major challenges to agricultural sector development in the county. This is followed by identification of the main climatic hazards based on the analysis of historical climate data and climate projections including scientific assessment of climate indicators for dry spells, flooding and heat stress among other key climate hazards for agriculture. The document continues with an analysis of vulnerabilities and risks posed by the hazards on the respective value chains. Based on these vulnerabilities, current and potential on-farm adaptation options and off-farm services are discussed. The text also provides snapshots of the enabling policy, institutional and governance context for adoption of resilience-building strategies. Finally, pathways for strengthening institutional capacity to address climate risks are presented.

1 Source: GoK; UNDP (2013). This index is relatively low, a factor that may arise from data paucity in the construction of the index
2 Source: https://www.standardmedia.co.ke/article/2000223147/government-to-use-sh600-million-to-buy-livestock-from-mandera-pastoralists
3 Source:http://www.nutritionhealth.or.ke/wp-content/uploads/SMART%20Survey%20Reports/Mandera%20Central%20SMART%20Survey%20Report%20-%20June%202014.pdf
4 GoK (2014b).
5 Source: http://practicalaction.org/blog/tag/mandera/page/2/
6 Source: http://www.napad.or.ke/publications/NAPAD_Mandera_Needs_Assessment_Report(2015).pdf
7 Source: http://www.irinnews.org/news/2008/11/05
8 Source: Fitzgibbon (2012).

Agricultural context

Economic relevance of farming

Mandera County is located in the north-eastern part of Kenya. It is bordered by Wajir County in the south and west, Ethiopia in the north and Somalia in the east. The county covers an area of 25,991.5 Km^2, 95% of which is arid. The county receives an average annual rainfall of approximately 255 mm (GoK, 2013); with the long rains falling in April and May whereas the short rains fall in October and November. The topography is generally flat and low lying except for a few rocky hills that rise to between 400 and 700 meters above sea level. Based on rainfall amounts and crop suitability, the county is divided into 2 main agro-ecological zones (AEZs) namely Lower Midland (LM) IV-VI and LM V-VI. The former is mainly found in Mandera east, Mandera west, Mandera south and Banisa sub-counties whereas the latter is found in Lafey (KNBS, 2015).

Despite the unfavourable climate conditions, agriculture is the major livelihood in the county employing over 90% of the population. The livestock sub-sector is predominant, engaging over 84% of the county's population[9], and contributing approximately 72% to household incomes (KNBS, 2014; KNBS, 2015). There is almost an equal engagement in agriculture of adult female- and male-headed households in the county and a significantly lower engagement of the youth-headed households[10] according to the Agriculture Sector Development Support Programme (ASDSP) of 2014. The difference may be due to the fact that the youth may be involved in alternative off-farm livelihood activities. Crop production on the other hand contributes to employment of less than 30% of the population and is mostly concentrated along the Daua River. The high dependence of the agriculture sector on rainfall compounded with institutional factors such as weak land tenure regulations render the county very vulnerable to acute food insecurity in the event of droughts.

People and livelihoods

According to the Kenya Population and Housing Census (GoK, 2009), the population of Mandera County was 1,025,756 persons (559,943 male and 465,813 female representing 54.6% and 45.4 % respectively) and was projected to grow at 3.96% per annum to stand at 1,399,503 by 2017. Around 87.5% of the county's population live in rural areas. The absolute poverty level[11] is 89.1% compared to the national average of 46% making the county's people among the poorest in the country. Poverty is highest in the rural areas where close to 100% of the population live below the poverty line (KIPPRA, 2013). The high poverty incidence can be attributed to the generally poor performance of the agriculture sector as well as to the limited livelihood options considering that only 17% of the households have more than one income source on average (GoK, 2014a).

Mandera County also has a significantly low Human Development Index (HDI) of about 0.42 relative to the national HDI of 0.52 (GoK; UNDP, 2013). The disparity is mostly due to the poor quality of life in the county with regard to access to basic amenities. For instance the literacy level is not only very low, standing at 25% compared to the national rate of 71.4% but is also characterized by a large disparity between the males and females[12]. Only 5% and 25% of Mandera County residents have secondary and primary school level of education respectively, while 70% have no formal education (KNBS, 2013). The low literacy level in the county which is as a result of the pastoralists lifestyle, the high levels of poverty, the shortfall of teachers and retrogressive cultural practises like early marriage, is a major impediment in achieving the county's human resources development objectives.

In Mandera County, 38% of residents use improved sources of water, with the rest relying on unimproved sources. There is no significant gender differential as 38% of male-headed households and 39% of female-headed households use improved water sources respectively (KNBS, 2013).

Access to clean modern energy sources is low with less than 1% of residents in Mandera County using Liquefied Petroleum Gas (LPG), while 93% and 6% use firewood and charcoal respectively. This poses a great threat to environmental management in the county, leading to deforestation, soil erosion and increased flood risk, due to cutting of trees for fuelwood. Only 3% of residents in Mandera County use electricity as their main source of lighting. A further 33% use lanterns, and 13% use tin lamps. Electricity use is mostly common in female-headed households at 5% compared with male-headed households at 2% (KNBS, 2013). The difference in access between male- and female headed

9 The figure are author's calculation from information in the NAPAD (2015).

10 For this study and the reference used, youth refers to both male and female above the age of 18 but below 35 years, whereas adult refers to either male or female above the age of 35.

11 Basic Report on Well-being in Kenya Based on Kenya Integrated Household Budget Survey-2005/2006

12 The male are comparatively well-off than the female (KIPPRA, 2013).

households would be as a result of many development initiatives targeting the female headed households hence the better access.

Food insecurity in Mandera County is high with 78% of the households reportedly being food insecure (GoK, 2014a) while approximately 31.8%, 18.6% and 41.2% of children in the county are stunted, wasted and underweight respectively (GoK, 2013). Low food diversity, partly caused by limited production of diverse crops due to harsh weather conditions is one of the contributing factors to the high malnutrition levels in the county. Unavailability of food especially during the dry periods results in low caloric intake as people skip meals.

There are three major livelihood zones in the county, namely the irrigated crop zone (the riverine zone), the agro-pastoral zone and the pastoral livelihood zone where approximately 32%, 39% and 28% of the population reside respectively (GoK, 2014b). Crop farming thrives along the river occasioned by irrigation where fruits and vegetables are produced. These include mangoes, paw paws, water melons, guavas, lemon, and bananas in addition to vegetables such as kales, onions, tomatoes and capsicum among others. Maize, sorghum and cowpeas are grown in the agro-pastoral zones such as Mandera west, Mandera east, Mandera north, Lafey and Banisa. Other important economic activities in the county include bee-keeping, trade within and outside the county and artisanal mining. The average annual on-farm income is KES 38,992 with the male- (KES 42,859) and youth-headed households (KES 31,522) having higher incomes than female -headed households (KES 19,014). Male-headed households have more income sources than either the female- or youth-headed households. Wage earners represent 38.9% and 17.1% of the urban and rural populations respectively. A large percentage of the population is self-employed in the livestock, agriculture and trade sub-sectors. The youth are the highest contributors (41%) to labour (both family and hired) used in farming activities, along with adult males (31%) and adult females (28%) respectively.

Agricultural activities

Land in Mandera County is communally owned with only the urban centre of Mandera town which represents less than 1% having title deeds. Agricultural activities are limited due to unavailability of water and saline soils in some areas that compromise crop production. The average farm sizes along Daua River range between 1-2 hectares, and the large-scale farms range between 5-15 hectares in the rain fed areas (GoK, 2013). Crop production is practised on less than 1% of the total county land area with no cash crops planted.

Livestock production and production of crops under rain fed conditions take place in all the sub-counties, whereas crop production under irrigation is mostly done in Mandera east, Mandera north, Banisa and Lafey. The main livestock types are goats (Galla breeds), camels (Somali breeds), cattle (Boran breeds), sheep (Somali black head breeds) and donkeys (Somali breeds). According to the County Directorate of Livestock Production, in 2016 it was estimated that there were 863,625 cattle, 1,016,700 camels, 3,415,440 goats, 1,164,280 sheep, 56,874 chicken, 13,068 beehives and 208,126 donkeys in the county. The livestock are kept for meat and/or milk production. The major crops produced under irrigation especially along the river Daua are maize, sorghum, simsim, kales, cowpeas, onions, tomato, spinach, mango, banana, lemons and watermelon. This river, traverses the county (150 Km) and provides an irrigation belt of about 20,000 ha. However only 4000 ha representing 20% of the irrigation potential is exploited (GoK, 2013). Maize and cowpeas are the main crops under irrigation taking up approximately 51% and 30% of the irrigated area respectively[13]. The huge irrigation potential in the County therefore remains untapped with only 18% of the households using irrigation water as an input (GoK, 2014a). Capitalizing on this huge irrigation potential would ensure that crop productivity is increased to supplement livestock production and to improve the food security status of the county in general.

Input use in crop production is generally low attributable to various factors including high poverty levels, high input prices and long distances to input markets among others. According to the ASDSP Household survey, 97% of the households who grow grains use the local seed (GoK, 2014a). Other management practises include the use of basal fertilizer and manure. However, manure is only used by less than 10% of the households in the county. The low use of manure can be linked to the non-sedentary nature of the inhabitants of the county who frequently move with livestock in search of pasture and water. High poverty levels and the long distances to input markets negate any efforts by the farmers to increase the use of inputs.

13 Calculated from KNBS (2015).

Livelihoods and agriculture in Mandera

Demographics

3% Of Kenya´s population

1,025,756 inhabitants

88% Live in rural areas

45% 55%

Access to basic needs

89% of the population lives in **absolute poverty**

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

Food security

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

ND of household **income spent on food**

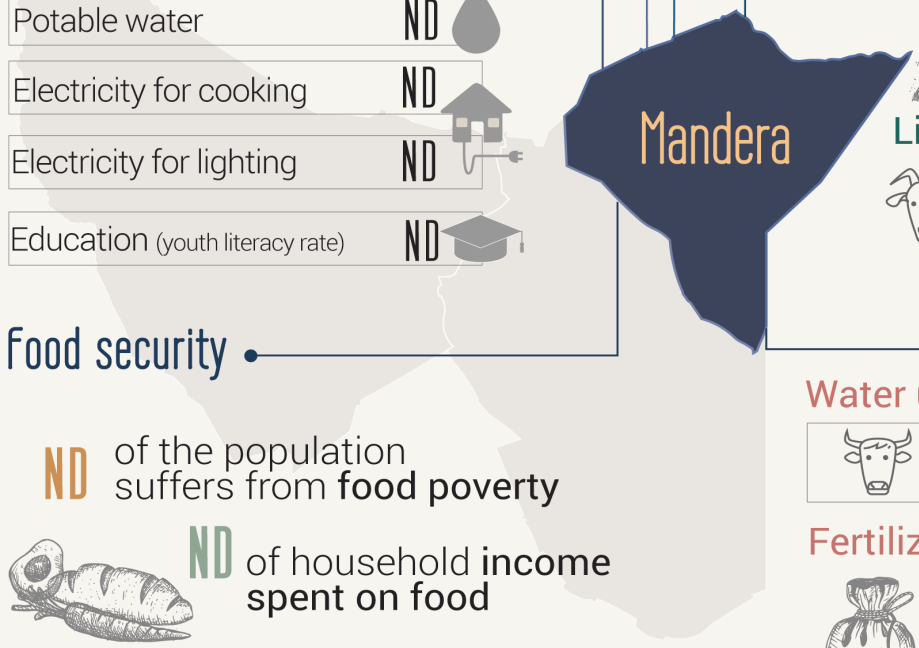
ND People **undernourished**

36% Children **stunted**

15% Children **wasted**

ND: No data

Infographic based on data from the County Integrated Development Plan (GoK, 2013), the Agricultural Sector Development Support Program (GoK, 2014), and Kenya National Bureau of Statistics (KNBS, 2015)



Farming

County´s farming area

ND ND

ND of the population employed in agriculture production

ND of farmers have title deeds

ND are women

Farming activities

Food crops

ND

Cash crops

ND

Of county´s agricultural land

Livestock

ND Group ranches

ND Company ranches

Farming inputs

Water uses

ND ND ND

Fertilizer types (% of households)

NPK

7% Organic manure

1% Planting fertiliser

ND Top dress fertiliser

Pesticide types (% of households)

ND Field pesticides

0.5% Storage Pesticides

11% Herbicide

Agricultural value chain commodities

A broad diversity of agricultural commodities are grown in the county. Of these commodities, various value chains have been prioritized as being strategic for the county as indicated in the County Integrated Development Plan (CIDP) and the Agriculture Sector Development Support Programme (ASDSP) as well as by government institutions such as the Kenya Agricultural and Livestock Research Organization (KALRO). For the development of this County Climate Risk Profile, four major value chain commodities (VCC) were selected for in-depth analysis based on: prioritization in County frameworks and programmes; economic value (KES/bag or KES/animal or KES/unit livestock product)[14]; resilience to current weather variability and future climate change[15]; and number of economically active people engaged in the commodity's value chain (including vulnerable groups, women, youth and the poor[16]). The prioritized VCCs for the county were camel milk, goat meat, sorghum and tomato.

Camel (milk)

Camels are found in all the agro-ecological zones (LM4-LM6) in the county and are kept by a large portion of households in Mandera County, with between 80-100% of the households being engaged in camel rearing in one way or another. The number of camels owned varies from an average of 10 camels per household (in Rhamu division) to as high as 60 camels per household (Takaba). Camel rearing is practised by both small-scale and large-scale pastoralists. The farming systems practised in camel rearing areas are mainly free ranging with some commercial camel farming being practiced in Banissa, Takaba and some parts of El Wak. According to the County Livestock Production Office, there are approximately, 1,016,700 camels in the county and in 2016, the County Directorate of Livestock Production, estimated that camels produced 1,396,058 litres of milk valued at about KES 111,684,640. Camel milk produced in the county contributes immensely to food security and income generation.

Men and youth are the main actors in the camel value chain who do activities such as grazing, watering and vaccination. The grazing strategy normally involves moving with the camels from place to place in search of pasture. Men are also involved in transportation of milk to marketing centres. Women on the other hand are involved in milking and milk sales normally at farm gate to brokers who then transport it to shopping and urban centres. Currently there are no large-scale brokers of milk and neither are there processors.

Goat (meat)

Goats are the most common livestock type kept in Mandera County. They are kept by almost all the households with 80-100% of the population engaging in goat rearing. Goats are found in all the agro-ecological zones (LM4-LM6) of the County. Estimates by the County Directorate of Livestock Production indicate that there are 3,415,440 goats in Mandera County out of which 111,600 goats valued at KES 446,400,000 were sold in the year 2016. Goats do well in the arid and semi-arid environment of the county as they can feed on shrubs (otherwise not palatable to most of the other livestock) which are the predominant vegetation.

Goat meat rearing is practised by small- and large-scale farmers mostly under extensive management system. Both men and women are engaged in goat production, and unlike other big livestock such as cattle and camel. Women are allowed to own and sell goats and even decide on how to spend the proceeds. Goats are sold at local livestock markets to both small-scale and large-scale traders. The large-scale traders accumulate large numbers of stock for onward sale to regional markets as well as major towns such as Nairobi and Mombasa. It is also important to note that Mandera being a frontier county, there is free livestock movement among the neighbouring countries of Ethiopia and Somalia. All these countries are therefore potential sources of livestock for sale.

Tomatoes

Tomatoes are grown mostly along the Daua River which runs across several sub-counties. These include Mandera east, Mandera north, Lafey and Banisa. This zone is referred to as the irrigated livelihood zone. Tomatoes are also grown in the hinterland. About 61-80% of the county's population are engaged in this value chain. Both the improved and local varieties are produced in the county with the improved varieties mainly grown along the irrigated livelihood zone, Local varieties are grown in the hinterland due to their hardy nature. According to the County Directorate of

14 As stated in the 2015 Economic Review of Agriculture (ERA) (Republic of Kenya, 2015))

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

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

Agriculture, the area under tomato production in 2016 was estimated at 190 ha from which 1,345 tons of tomatoes worth KES 80.7 million were produced.

Most tomato farmers in the hinterland are small-scale while the riverine zone (where irrigation takes place) is dominated by medium- and large-scale farmers. Men, women and youth are heavily involved in the production considering that tomato is a high value crop. The tomatoes are consumed locally while some are exported to other counties generating considerable income to the locals. Urban centres where traders converge and aggregate the produce are the main markets for tomatoes. Youth and women play a major role in marketing with youth serving as middlemen or brokers in aggregating the produce for volumes before selling to large-scale traders who then transport the produce for sale in markets outside the county.

Sorghum

Sorghum is a drought tolerant crop grown by small-scale farmers for food and livestock feed, largely due to its ability to withstand the harsh climatic conditions of the county. Between 61-80% of the total population are estimated to be engaged in sorghum production, and according to the County Directorate of Agriculture, the area under Sorghum production in 2016 was 750 ha from which 195 tons worth KES 4.3 million were produced. The importance of sorghum as a food security crop and livestock feed cannot be underscored. Most economically challenged farmers in the county prefer growing sorghum since it has better yields than maize under dry conditions. There is a marked preference for the white sorghum (Gooseneck, Gadam, and KARI Mtama 1) as opposed to the red variety. Efforts to promote the red variety have not been successful since it is considered less palatable due to high tannin content. Commercialization of the crop is yet to be realized.

Women and youth are heavily involved in the value chain right from production to marketing. The youth are mainly involved in spraying, weeding, harvesting and transportation of the crop.

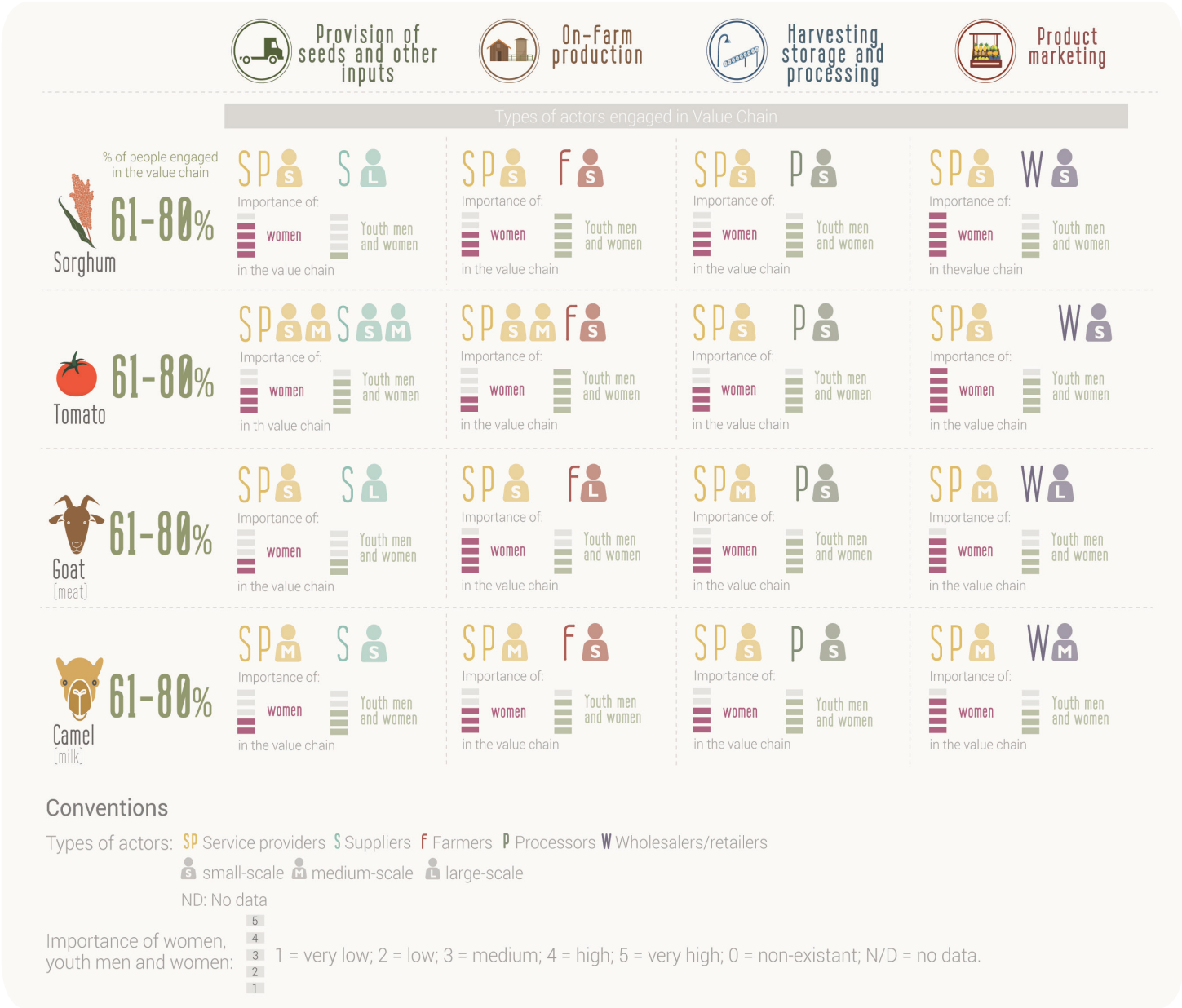
Agricultural sector challenges

Despite abundance of land in Mandera County, significant crop production is confined to areas along the river due to the adverse weather conditions especially recurrent drought. The impact of drought on the crop and livestock sub-sectors is twofold; first, scarcity of water and pastures during dry periods results in crop failure and reduced livestock production that frequently lead to food insecurity, and secondly the food insecurity adversely impacts the agricultural labour productivity, resulting in low agricultural productivity. In the same measure, flooding along Daua River as a result of heavy precipitation in the Ethiopian highlands imposes huge losses due to destruction of assets and crops, as well as drowning of livestock.

In addition to the aforementioned, saline soils found in most parts of the county and the invasion of the Prosopis juliflora (mathenge) are great hindrances to crop farming. This is further exacerbated by the prevailing high poverty levels in the county. This coupled with low literacy levels; pose a great challenge to adoption of modern farming and livestock production technologies by farmers and pastoralists in the county. The poor road network within the County restricts movement of both people and goods, denying the residents the benefits of better market access and prices for their produce. This situation is worsened by the minimal value addition and poor access to services for instance storage hence the high post-harvest losses. Food insecurity and scarcity of clean water contribute to prevalence of human diseases which hinder agricultural productivity. The livelihoods of pastoralists are also affected by livestock diseases such as bovine rinderpest (RP), Peste des petite ruminants (PRP) which affects small stock such as goats and sheep; and Contagious Bovine Pleuropneumonia which affects cattle and camels. These diseases often decimate livestock herds during outbreaks. The high cross border mobility of livestock complicates the surveillance, management and treatment of livestock disease.

Mandera County being a frontier county is faced with security challenges internally and from the neighbouring countries. This has made it difficult for farmers and pastoralists to access inputs and extension services due to reduced mobility of service providers. High cost of farm inputs and limited access to credit facilities (in part due to few Sharia compliant financial institutions) for the resource poor pastoralists and farmers is a major problem in the county. Paucity of processing facilities in the county for both crops and livestock products means minimal value addition is undertaken and therefore the products fetch lower prices. High post-harvest losses also occur due to the high temperatures. This coupled with the poor road network and poor market infrastructure only makes

Agricultural value chain commodities in Mandera



matters worse for the farmers and pastoralists in the county.

Lastly, communal land ownership discourages long-term investments on the land. The rugged terrain negates any advantages that could otherwise be associated with the vastness of the county. This makes acquisition of inputs, sale of produce and access to agricultural services more challenging. The outcome of these challenges is a high rate of dependence on food aid and relief programmes by a large section of the population in the county.

Climate change-related risks and vulnerabilities

Climate change and variability: historic and future trends

Mandera County is generally dry and hot and therefore unsuitable for rain fed crop production. Mean annual temperatures are often above 25°C in most parts of the county. However in the northwestern part of the county, mean annual temperatures range from 23°-24°C. Annual average rainfall is 255mm, with the

eastern part of the country receiving an annual average below 250mm. The factors make Mandera one of the driest counties in Kenya, with a high vulnerability to drought, heat stress and moisture stress. Mandera was among the counties hardest hit by the prolonged drought experienced in early 2017, that left livestock in dire need of water and feed. The County government and development partners responded by water trucking and provision of feeds in order to curb any further livestock emaciation. Flash floods also occur due to episodes of intense rainfall. However drought remains the greatest threat to agricultural production and livelihoods in the county.

Analysis of historical temperature trends in the county over 25 years (1981 to 2005), indicate that mean first season temperatures have increased by approximately 1°C, while second season temperatures have moderately increased by 0.2°C. In addition to these temperature changes, analysis of precipitation trends over a 35 year period (1981-2015) showed that average first season rainfall had decreased by almost 50mm, however average second season rainfall had increased slightly. As a result of these changes in temperature and rainfall, both seasons have experienced an increase in the number of heat stress days, with the first season experiencing a larger increase. There has also been a marked increase in flash floods in the second season with rainfall intensity increasing along with the increase in precipitation.

Looking ahead to the future, climate projections based on two representative concentration pathways (RCP 4.5 and RCP 8.5[17]) indicate that under both scenarios there is expected to be a continued increase in mean temperatures in both seasons. The rising temperatures are expected to result in a continued and marked increase in heat stress days by at least 25 days in the first half of the year (up from just over 45) and by at least 8 days (up from approximately 3 days) regardless of the emissions levels. Changes are also expected to occur in season onset and duration. A moderate increase in the length of the second season is expected under the high emissions scenario, and an early start of both seasons combined with a slight decrease in the length of the second season projected under the low emissions scenario. Under both scenarios slight reduction in average annual precipitation is expected in the first season compared to historical averages. However, under the high emissions scenario average second season rainfall is expected to rise slightly. Rainfall intensity under both scenarios is also expected to increase along with an associated increase in flood risk in both seasons. Although the projections under the two GHG emissions scenarios show some differences, both indicate the possibility of increasingly variable rainfall, shifts in season onset and duration, and continued rises in temperatures with these resulting in an increased risk of droughts, dry spells and floods.

Climate Perceptions by the farmers

From the farmers and pastoralists point of view, variations in climate conditions in the county have appeared in various forms, with mostly negative implications on their livelihoods. Farmers and pastoralists alike have in the past relied on the long rain season (Jan-June), however these are said to have changed with the long rains having not only remarkably reduced in amount but also become more erratic, unreliable with marked delays in season onset. The short rains, normally received in the second half of the year, have also become more unreliable, negatively affecting both crop and livestock production.

Farmers indicated that prolonged droughts have resulted in increased depletion of water resources from year to year and most rivers in the county have dried up, with the conventional accession of water by pastoralists through digging out sand in dried river beds no longer being viable as the water table has fallen. Farmers cited as an example, the Daua River which used to provide water for up to 9 months in a year without drying but can today only provide water for a few months. The upshot of these changes has been scarcity of water resources and livestock feed that culminates to conflicts between crop farmers and pastoralists.

Human and livestock disease incidences have increased compared to the past. For instance, pastoralists have incurred great losses due to decimation of camels by a mysterious disease yet to be identified. Human diseases such as dengue fever and Chikungunya disease that never existed in Mandera have emerged (IGAD, 2016); all attributable to the variation in the climate conditions. These diseases affect families in terms of availability of labour and also put a strain on their meagre financial resources which are diverted to healthcare costs.

Pastoralists have also seen the disappearance of grass varieties especially the perennial types such as

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

Paspalidium desertorum, Digitaria aridicola, Aristida adoensis, Chrysopogon plumulosis and Cymbopogon schenanthus which used to form an important part of their pasture. Contrary to the aforementioned, there is a proliferation of invasive weeds such as *Prosopis Juliflora* popularly referred to as "mathenge". The weed is known to have adverse effects on livestock since excessive consumption of the pods is harmful to livestock; though some pastoralists collect the pods to feed their goats. In as much as "mathenge" is harmful to livestock as a feed, it is useful for charcoal production which is an income generating activity in the county.

Climate vulnerabilities across agriculture value chain commodities

Climate variability and change pose serious threats to agricultural production and livelihoods in Mandera County. Considering past climatic trends and future projections, drought and increasing temperatures, were identified as posing the greatest risks to overall agricultural production and livelihoods in the county. However, when looking at the prioritized value chain commodities individually, these are expected to be impacted differently by different hazards. The following is an account of the two main hazards affecting each value chain along with the current coping strategies and suggested longer term adaptation actions.

Camel (milk)

Camel milk production is mainly affected by drought and late start of seasons, hazards which are prevalent across the entire county. On-farm production is affected by reduced pasture and browse availability due to moisture stress, increased distances to water sources, low breeding rates and increased disease incidences caused by poor body condition of the animals. Drought also results in reduced milk production and supply which can result in increases in market prices. The shelf-life of milk is also reduced due to high temperatures resulting into increased losses.
High temperatures make herding an arduous task, pastures dry up and water availability reduces due to high evaporation. Important practices such as deworming and vaccination are significantly hampered by high temperatures hence pastoralists rarely undertake them. This increases the risk of and susceptibility to pests and diseases, sometimes resulting in animal mortalities. High temperatures also lead to low breeding rate success due to poor body condition hence low productivity. Milk production during droughts and heat spells is often much lower than normal, due to poor feeding and animal heat stress.

The low altitude areas are especially prone to high temperatures and heat waves, as well as being characterised by low rainfall which affects the availability of water and pasture. The intrinsic cultural value of keeping large herds of camels exposes the pastoralists to greater risks. Since most of the pastoralists are resource poor, they are unlikely to afford to alternative feeds. Limited extension coverage coupled with poor road networks compromise the resilience of the pastoralists.

Goat (meat)

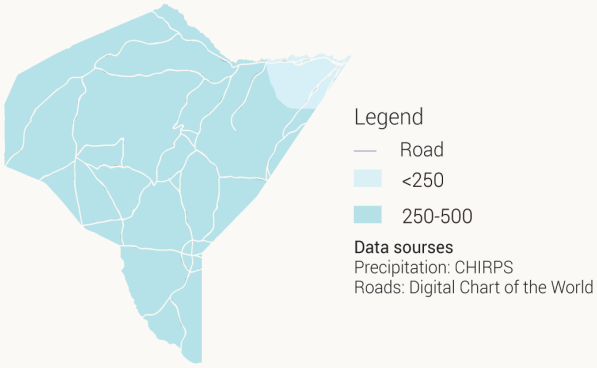
The goat meat value chain has been noted to be particularly affected by drought and late start of the seasons. These climatic hazards affect all the stages of the goat meat value chain. Despite goats being relatively hardy and resilient to drought conditions, drought still causes scarcity of the replenishing stock, poor health of the existing stock and increased demand and costs for veterinary services. Drought also results in reduced forage availability for goats (and therefore low live weight due to poor body condition), poor quality feed, increased distances to watering points and pastures, low breeding rates and high costs of management such as vaccination and treatment. Drought eventually leads to low prices to farmers for live animals due to poor body condition and in the long run higher prices for consumers caused by deficits in supply of quality animals and meat. Markets are also affected by irregular and unpredictable supply of goats due to the effects of drought. Goats feed on the shrubs and herbs that grow naturally in the County and therefore any reduction in the shrubs and herbs will have a negative effect on goat meat production.

In terms of season onset, a late start of seasons causes prolonged feed scarcity especially if this occurs immediately after a drought. This leads to poor quality feed, poor body conditions of the animals, increased treatment costs and reduced availability of replenishing stock. This negatively affects breeding and hence the number of animals produced. The low volumes and low quality of animals in this period often results in reduced supply to the markets and increased market price. In some instances, acute feed shortages lead to increased offtake of livestock where animals in poor condition are taken to the market and fetch very low prices.

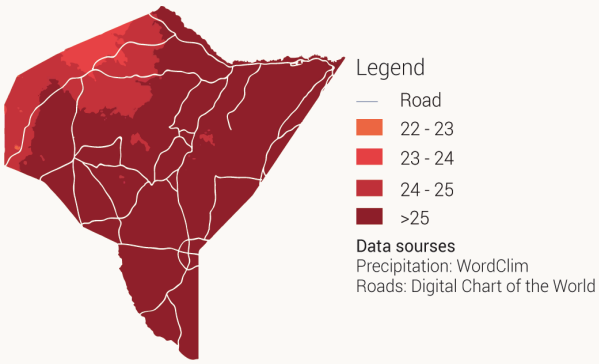
Uneven distribution of pasture during the time waiting for the season to start, and which are exacerbated by differences in soil type, quality and fertility often result in pastoralists having to move to find pasture and fodder. Areas in low altitudes are more prone to low rainfall and irregular seasons both of which

Past and future impacts of climate hazards in Mandera

Historical annual mean precipitation (mm/year)



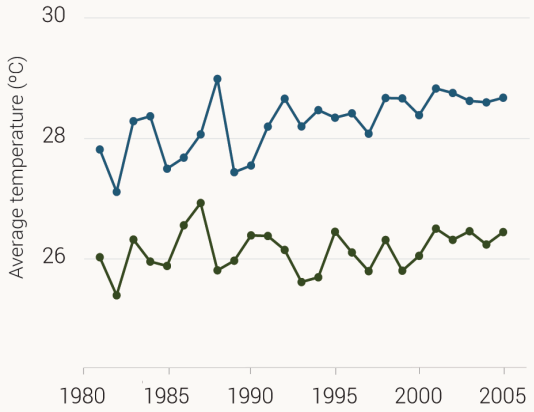
Historical annual mean temperature (°C)



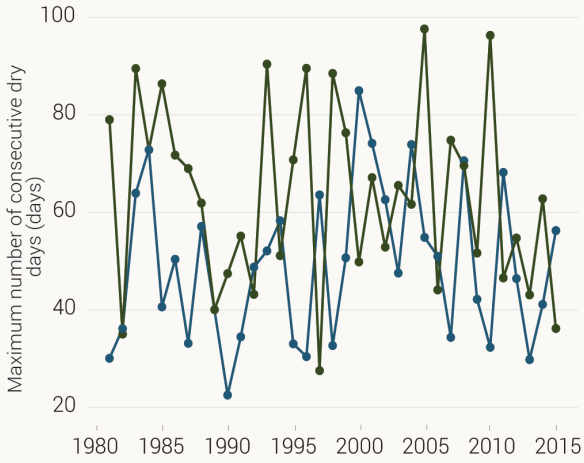
Heat stress hazards

Drought hazards

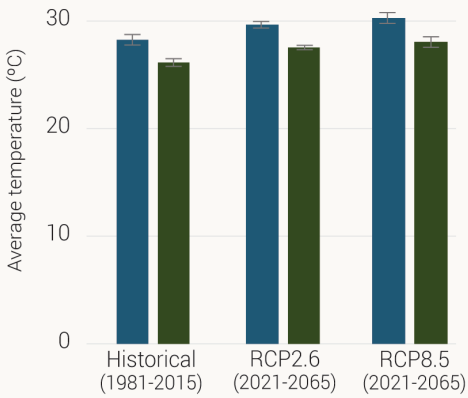
Historical extreme heat stress events



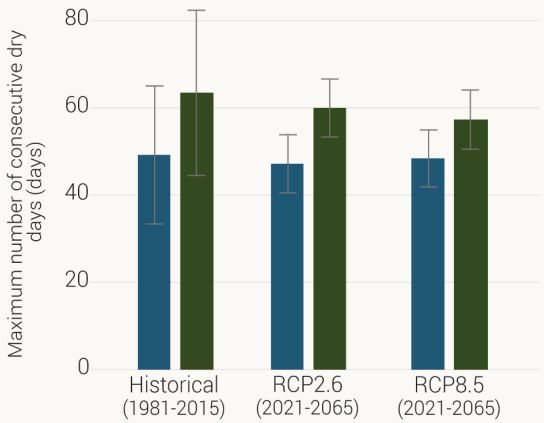
Historical drought stress events



Historical and expected extreme heat stress events



Historical and expected drought stress events



January - June July - December

have a large effect on pasture and water availability. Worsening the vulnerabilities of the goat keepers is the slow recovery of the pastures caused largely by the high animal numbers which often cause environmental degradation as well as the occurrence of repeated, more severe and more frequent droughts that do not allow for the vegetation to fully recover.

Sorghum

Sorghum is a drought-tolerant crop that does well in soils with low fertility, typical of those found in Mandera County. Nevertheless, extreme weather events such as droughts, dry spells, heat waves and changes in season onset and duration affect its productivity. For instance, drought causes hardening of the soils making land preparation an arduous task.

There is often low demand for and use of inputs such as seeds and fertilizers during drought periods as farmers take a cautious approach to minimise risks and potential losses. Drought can result in low germination rates thus forcing farmers to replant, while at advanced stages of growth, drought causes severely reduced yields and in some cases total crop failure. During drought there is often increased incidence of pests and diseases particularly small birds which feed on the sorghum grain before it has been harvested. Droughts ultimately result in low harvests, reduced supply to markets, and higher prices for consumers.

Another hazard, affecting sorghum production in the county is the late start of seasons, which causes uncertainty in planting dates and timing of other farm operations such as land preparation and timely acquisition and application of inputs. Uncertainty of season onset can lead to reduction in acreage, while untimely planting and application of fertiliser and pesticides can often result in reduced yields. Irregular season onset can often result in poor germination rates when rains do not fall when expected, while changes in season duration can at times lead to crop failure. The end result is usually low quantity and quality of sorghum yields, and reduced amounts available for both consumption and sale with an increase in market prices.

It is important to note that sorghum is grown mainly by poor farmers who depend on it for food security and are least able to cope with the hazards that affect its production and marketing. The hazards affecting sorghum production are compounded by limited extension coverage and limited access to agro-weather information and advisories that inform decision making by farmers and ultimately their resilience to weather variability and climate change.

Tomato

Tomato is one of the high value crops grown in Mandera County. Tomato farming is a capital-intensive venture and therefore poor farmers are highly vulnerable to the hazards which affect its production. These hazards include intense rains and high temperatures, which affect tomato production particularly in the low-lying areas along the Daua River basin and in the hinterlands. Here flash floods from intense rain often wash away tomato seedlings and plants as well as fertilizers and pesticides resulting in high cost of production. Floods also worsen the poor state of most roads rendering them impassable, not only impairing access to agricultural inputs and increasing their prices but also limiting access to output markets. Impaired access to output markets often results in losses to farmers who have to reduce prices or risk losing the highly perishable produce. The quality of the tomatoes can also be compromised due to delayed delivery to markets caused by impassable roads. Intense rains also affect land preparation, planting and harvesting all which are more difficult when the land is water logged. Due to reduced supply and increased transport costs during periods of intense rains, consumer price increases are inevitable while the returns to producers drop significantly.

High temperatures on the other hand are associated with reduced seed viability, poor seed germination, wilting of seedlings and tomato plants, and increased disease and pest infestation. High temperatures increase the perishability of tomatoes, with harvested fruits often deteriorating rapidly during transport and at the market resulting in low prices for farmers and traders.

Adaptation to climate change and variability

The capacity of pastoralists and farmers to adapt to changes in climate is impeded by various climatic, biophysical and institutional factors. Agricultural productivity in Mandera County is first and foremost challenged by water scarcity and pressure on the natural resource base. The arid and semi-arid nature of the county provides limited options for farmers to diversify their crop enterprise due to the fewer choices of crops that can survive the harsh climatic environment and the saline soils. Overstocking of livestock is a common underlying factor in the county, as livestock are regarded as a sign of wealth while cultural inhibitions restrict the sale of animals even during drought. The poor road infrastructure network

compounds the problem of accessibility within the county, particularly when faced with hazards such as floods and intense rainfall which can render already difficult to access areas inaccessible. This hampers access to input and output markets as well as to basic extension and veterinary services.

Farmers and pastoralists alike have adopted various strategies to address the risks presented by weather variability and climate change but the adaptation strategies have not cushioned them from the vagaries of climate due to high poverty levels, low literacy levels, poor infrastructure and cultural practises.

On-farm adaptation practices

Due to water scarcity, crop production is only viable in the river basin where farmers use irrigation as a productivity enhancing and adaptation practice. There is negligible irrigation in the hinterland due to the poor irrigation infrastructure largely due to the restrictively high establishment cost. In addition, most interventions in irrigation, for instance the provision of solar irrigation kits by Islamic Relief, are limited in the river basin. Nevertheless, sustainability is challenged by the low human resource and financial capacity.

Water harvesting and conservation is also an important intervention practised in Lagurere, Bulla Mpya, Takaba and Githere among other areas by approximately 30% of the households in Mandera County (GoK, 2014a). Some of the methods used for water harvesting include zai-pits[18], shallow water wells, semi-circular bunds, boreholes, construction of water pans with capacities of between 60,000 m^3 to 100,000 m^3. Water trucking is common as a relief measure, where water is delivered in trucks to strategic points in Banissa and Mandera west. Due to the scarcity of water and the need to better manage the environment, watershed management is common, particularly through the passing of bylaws regulating activities along the watershed.

For the livestock keepers, pasture and fodder production and conservation have become common coping and adaptation practices. Some of the fodder crops produced include Sudan grass and Boma Rhodes. Some irrigated fodder production is practiced along the river basin. The fodder is dried and used during times of livestock feed scarcity. Stores for keeping hay have been constructed in various sites across the county by the County Government through the Directorate of Livestock Production and other partners such as Consortium of Cooperating Partners (COCOP), and Islamic Relief. It is important to note that in some instances, cereals like maize and sorghum grown in the county are not left to mature but fed to livestock especially during times of feed scarcity. There is a thriving market for fodder in the county with the resultant effect being more farmers venturing into fodder production, as an income diversification strategy. Farmers have also been offered support in terms of inputs such as seeds to increase pasture production. It is reported that 11% of households in Mandera County are practising feed conservation as a climate change adaptation strategy (GoK, 2014a).

Destocking of livestock during dry periods is another mechanism employed by pastoralists to adapt to drought, especially as a loss minimising strategy. This is done by selling some of the old or weaker livestock and retaining what they are able to manage. Destocking is normally encouraged and promoted by the national and the county government in partnership with NGOs during the drought period. Social networks play an important role in the resilience of agro pastoralists to hazards; for example, when pastoralists lose their camels to drought, the wealthy pastoralists donate some of their animals to the poor pastoralists to restock in line with their faith.

Migration is a key coping strategy for pastoralists in times of drought. Pastoralists often move with their livestock in search of pasture and water. Some of the preferred migration sites are along the river basin and areas bordering Ethiopia which are replenished by rains from the Ethiopian highlands. Migration of livestock is not restricted to the above mentioned areas but is informed by availability of pasture, often across county boundaries, with pastoralists moving their livestock into neighbouring counties such as Isiolo, Wajir and Garissa.

Afforestation through on-farm tree planting is supported by the Kenya Forest Service (KFS) in Mandera County through the provision of seedlings. KFS also supplies seedlings to schools and institutions for planting to improve tree cover. In addition, KFS also provides environmental education to the communities through seminars on the importance of planting and protecting the trees. The trees are also planted near water sources to protect the water catchment areas. The most preferred tree species is the Neem tree (*Azadirachta indica*) which is a drought resistant multi-purpose tree whose uses include firewood, charcoal, timber, fodder, shade, medicine, soil fertility improvement, erosion control and insect repellent. According to ASDSP,

18 ISmall pits dug around a crop during the pre-season period so as to hold water when the rains come.

31% of households in the County are engaged in tree planting as a climate change adaptation strategy (GoK, 2014a).

Greenhouse technology is being undertaken by farmers in the county to ensure efficient water use and also guarantee production throughout the year. Greenhouses have been established in all the sub-counties of the county, however the cost of the structures inhibits their adoption by resource poor farmers.

Another key adaptation strategy is the planting of drought tolerant crops to circumvent the challenges posed by climate change. Some of the drought-tolerant crops include; sorghum, dryland maize, cowpeas and green grams. These crops efficiently utilize the little rainwater that is available for crop production since they have short crop cycle and can also withstand long dry spells. Interventions with high potential in the county include semi-intensive grazing (reduced migration), feed production and conservation, livestock product value addition, conservation agriculture, improvement of local varieties and communal seed bulking for the crops. Longer term strategies include the construction of abattoirs and improved storage facilities for vegetables, meat and milk, as well as the development of large water reservoirs (dams).

Off-farm adaptation practices

There are several off-farm agricultural services currently being offered in Mandera County. The Kenya Meteorological Department (KMD) provides weather forecasts for the long and short rainy seasons. This gives information on the amount and spatial distribution of the rains and thus helps the farmers make informed decisions on the type of crops to grow. Despite this information being offered to the pastoralists, it is not always accessible to all in a timely manner due to the wide distribution of pastoralists across the county. While seasonal forecast are often useful for seasonal planning, improved agro-meteorological advice for shorter temporal scales would be of greater use for informing decisions within the season. In addition pastoralists need to be sensitised on the usefulness, limitations and application of the weather information. In the same vein the National Drought Management Authority (NDMA) generates and disseminates the early warning information on a monthly basis. This helps to trigger timely responses to impending crises identified by the assessments. The NDMA is also involved in capacity building of communities and stakeholders in the county in matters related to climate risk management in order to empower community members to act in a timely and organised manner in the event of a hazard such as drought. Low literacy levels in the county however hampers the effective use of the weather information produces by the NDMA.

Livestock insurance is also available in the county, a risk management strategy that is promoted and implemented by the national government with the help of local insurance companies, supported by World Bank and other stakeholders such as The International Livestock Research Institute (ILRI) to cushion pastoralists from the adverse effects of climate change. Under the system, farmers are given a pay-out based on the status of the grazing conditions once a certain threshold is reached. This helps the pastoralists to provide food and water to the livestock to survive and avoid deaths. The insurance scheme is also used to underwrite livestock losses as a result of drought and to help pastoralists restock their animals after a shock caused by drought. Some of the challenges faced in implementing this strategy are the large number of livestock kept by the pastoralists, convincing pastoralists on the need for livestock insurance and the wide spread of pastoralists across the county which makes getting information to and from them difficult.

Micro-credit and microfinance programs are being championed by supporting pastoralists and farmers to form groups to access interest free loans and also learn to save to shield them against hazards. The Group Savings and Loans Association (GLSA) encourages members to embrace a saving culture, and also facilitates access to loans for members to diversify their income sources. This is critical in light of the high poverty levels witnessed in the County since it empowers the community. At the same time sensitization of micro finance institutions on the risks and benefits associated with investing in pastoralists and agro pastoralists is crucial in enabling them to provide better services to this unique client group.

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

Sorghum

	Provision of seeds and other inputs	On-farm production	Harvesting storage and processing	Product marketing
Drought/ Moisture stress	Lack of availability of seeds. Reduced purchase of pesticides and other farm inputs	Extra labour (and costs) in land preparation. Low seed germination rate. Wilting of crops. Crop failure	Low yields. Poor quality produce. Little processing. Little storage. Increased post-harvest weevil infestations	Most produce consumed on-farm hence low sales to markets. Shortages on local markets. Low returns for farmers and traders
Magnitude of impact	Major	Severe	Severe	Major
Farmers' current strategies to cope with the risks	Use of local more drought resistant varieties. Use of ash in place of pesticide. Integrated pest management (IPM) with neem tree, capsicum and hot peppers	Farming along laggas (places where water collects naturally). Use of conservation agriculture practices (minimum tillage). In field soil and water conservation methods. Early (dry) plantin	Early harvesting to avoid losses to pests. Use of traditional on-farm storage structures (kodo). Use of ash to reduce weevil infestations. Dehusking and grinding using mortar and pestle	Household consumption. Farm gate and local market sales. Marketing at agricultural shows and demonstrations. Sharing market information from farmer-to-farmer
Other potential options to increase farmers' adaptive capacity	Capacity build more farmers on IPM. Seed bulking. Capacity building on local certified seed production	Construction of check dams and stone bunds to increase water infiltration. Promote intercropping (with cow peas). Capacity building on appropriate spacing and plant density to minimise competition for water	Promote aided drying of produce (using dryers). Investment in processing machinery (dehuskers and posho mills). Invest in modern storage structures e.g. raised silos, hermetic bags	Support access to external markets. Improve feeder roads. Establishment of sorghum marketing association
Changes in seasons (onset and duration)	Unpredictable supply and availability of seed, fertiliser and other inputs due to uncertainty in season start. Loss of planted seeds. Limited purchase of pesticides and other agrochemicals	Low yields due to untimely planting. Failure to reach maturity. Reduced acreage under production. Uncertainty in planning farm operations	Reduced harvest and storage. Limited processing	Reduced income for farmers. On-farm consumption. Reduced quantities available for sales
Magnitude of impact	Major	Major	Major	Major
Farmers' current strategies to cope with the risks	Use of local drought resistant varieties. Seed selection from previous harvests. Seed preservation and storage using ash. Integrated pest management (IPM) with neem tree, capsicum and hot peppers	Infield basin construction. Contour farming on hilly land. Staggered planting. Early weeding. Use of indigenous knowledge to inform seasonal activities	Use of on farm storage facilities (bakaras, cribs and kodos). Home winnowing and hand beating. Demonstration of food utilisation (preparation of sorghum)	Household consumption. Farm gate and local market sales. Marketing at agricultural shows, bazaars and demonstrations. Sharing market information from farmer-to-farmer
Other potential options to increase farmers' adaptive capacity	Capacity building on seed conservation and bulking. Capacity building on appropriate seed selection (short season and early maturing varieties). Capacity build more farmers on IPM. Improve agrometeorological information	Construction of check dams and stone bunds to increase water infiltration. Investment in mechanised equipment to facilitate farm operations. Improve access to extension advice (planting dates)	Capacity building on product sterilisation and marketing. Promote aided drying of produce (using dryers). Construction of concrete storage facilities to safe guard harvests and seeds. Investment in modern raised grain silos. Investment in processing machinery (dehuskers and posho mills)	Support access to external markets. Improve feeder roads. Establishment of sorghum marketing association. Link farmers directly to processors (rather than middle men)

Tomato

	Provision of inputs	On-Farm production	Harvesting storage and processing	Product marketing
Intense rainfall/flooding	Flooding of roads results in reduced access to seedlings and other inputs. Flood damage to seeds and seedlings in nurseries	Delays and difficulty in land preparation. Difficulty in transplanting seedlings. Young seedlings may die due to excess water in the soil	Rotting of fruits in the field or in storage. Delayed collection due to impassable roads	Low volumes in the markets and quality is poor. Low market supply due to impassable roads. Low market supply and high prices for the consumers
Magnitude of impact	Moderate	Major	Major	Major
Farmers' current strategies to cope with the risks	Construction of gabions for flood control. Use of pest and disease resistant varieties. Use of raised seed beds for seedlings. Lower lending rates; expansion of repayment periods; suspension of farming by farmers; early supplies of inputs; early purchases	Minimum/zero tillage practices e.g. use of herbicides; use of IPM e.g. traps; use of selective herbicides; increased frequency of farm operations; use of raised nursery beds. In field drainage mechanisms (trenches and channels)	Delay harvesting until rains stop. Use of polythene sheets for covering the produce. Suspend collection until rains subside	Sales to middle men. Lowering of prices for low quality produce. Producer will deliver produce manually to most accessible point; middlemen determines the product prices; combining of transport to collection centres
Other potential options to increase farmers' adaptive capacity	Government seed supply to ensure production. Capacity building on improved seedling production - trays and treated cocopits for better nursery establishment. Repair and construction of access roads	Construction of large dams for flood control. More research on tomato pests (e.g. red spider mite). Capacity building on tomato management. Use of advanced technology for tomato production e.g. hydroponics (cocopits). Promotion of greenhouse farming	Investment in tomato processing facility. Construction of raised and covered sheds on farms	Repair and construction of access roads. Capacity building on tomato marketing. Capacity building of cooperatives in marketing and sales
Increased temperatures	Heat stress for seedlings. Wilting and death of some seedlings	Poor seedling germination rates. Heat affects farm labour. Frequent watering resulting in increased labour and financial requirements. Increased cases of pests and diseases	Poor quality produce. Fast deterioration of the harvested crop. Spoilage during transportation	Low prices due to low quality produce
Magnitude of impact	Moderate	Moderate	Moderate	Moderate
Farmers' current strategies to cope with the risks	Obtaining seeds and seedlings from government facilities or research organisations	Ploughing in the early morning and evening (cool hours). Mulching	Transport of produce during cools hours (early morning or evening). Shading of produce with grass. Limited processing	Use of middlemen to link the producer to the market. Farm gate sales to reduce chances of spoilage before sales
Other potential options to increase farmers' adaptive capacity	Promotion of drought tolerant varieties	Promote water harvesting and drip irrigation. Capacity building on tomato shading. Promotion of conservation agriculture (mulching, minimum tillage and intercropping)	Construction of a tomato processing plant in the county. Construction of shaded collection and grading centres. Training on tomato storage and value addition	Improvement of access roads to reduce transport times. Construction of shaded vegetable marketing centres

Goat (meat)

	Provision of seeds and other inputs	On-Farm production	Harvesting storage and processing	Product marketing
Drought/ Moisture stress	Low availability of stock for replenishment of herds. Scarcity of forage and feed. Scarcity of water	Poor health of herd. Poor body condition of herd. Increased mobility in search of water and pasture. Increased labor for farmers. Increased pests and diseases	Reduced market value of stocks. Reduced volumes for processing. Household consumption	Low prices of livestock for farmers. Reduced household income
Magnitude of impact	Severe	Major	Moderate	Moderate
Farmers' current strategies to cope with the risks	Water troughs near breeding stock. Fodder production. Feed supplementation.	Water trucking by government. Use of natural water pans. Government mass treatment and deworming campaigns. Movement of herd to water sources	Increased offtake (destocking). Home slaughtering and consumption. Meat drying	Local household consumption. Sales to middle men
Other potential options to increase farmers' adaptive capacity	Training on production and conservation of homemade feeds. Promote drought tolerant breeds. Enhanced drought early warning system	Training of community disease monitors. Scaling up water harvesting for livestock. Consolidated herding. Research on improved grazing management	Support value addition activities (meat drying). Construct abattoirs and cold storage facilities. Capacity building on appropriate destocking	Improved promotion of goat meat. Linkage of farmers to external markets and butcheries. Establish market information system for goat meat
Changes in seasons (onset)	Increased cost of feed. Poor quality of feeds. Reduced breeding	Reduced feed consumption resulting in slower growth. Increased water needs. Increased pest and disease management requirements	Reduced market value	Low prices of livestock for farmers. Reduced household income. Low volumes traded
Magnitude of impact	Moderate	Moderate	Moderate	Moderate
Farmers' current strategies to cope with the risks	Feed supplementation and fodder production and storage	Water trucking. Movement of herd to water sources. Culling of weak or ageing animals	Slaughter at household level. Sales of roasted goat meat. Drying/ smoking	Local sales and consumption. Sales to middle men
Other potential options to increase farmers' adaptive capacity	Training on silage production and feed conservation. Dissemination of feed formulation technologies and information. Promote drought tolerant breeds	Train farmers on construction of goat enclosures. Water and fodder cost sharing system between farmers	Establish shaded holding grounds and cold storage facilities. Construct abattoirs	Capacity building on marketing. Establish contract goat farming. Increase number of shaded sales yards. Use of goat auction system

Camel (milk)

	Provision of seeds and other inputs	On-Farm production	Harvesting storage and processing	Product marketing
Drought/ Moisture stress	Feed and browse scarcity. Animal death. Higher feed requirements (and costs). Reduced breeding	Reduced milk production. More time spent on tracking animals which have moved in search of fodder, browse and water. Difficulty in managing livestock health due to far distances animals migrate	Difficulty in collecting milk for bulking. Low volumes for bulking. High cost of transportation – buyers need to travel further into interior to look for milk	Disruption of milk market linkages. Reduced income for farmers. Increased price of the commodity for consumers. Less volumes available for sale
Magnitude of impact	Moderate	Moderate	Moderate	Moderate
Farmers' current strategies to cope with the risks	Movement of animals from place to place in search of better browse, pasture and water. Local (in) breeding	Water trucking. Movement of herd to water sources and better pastures. Government mass deworming and treatment	Consumption of milk at household level. Farmer groups for milk collection and sales using jericans. Destocking	Individual sales at local market or to vendors (middle men). Use of informal/passenger vehicles for transport to market
Other potential options to increase farmers' adaptive capacity	Promote artificial insemination. Feed and fodder production	Drilling of boreholes along livestock routes. Rainwater harvesting. Use of underground water tanks. Control cross border migration of animals to reduce spread of disease. Capacity building of community livestock health workers	Capacity building on milk handling and distribution of modern milk handling equipment. Construction of milk collection and cold storage facilities along strategic livestock routes. Use of aluminium containers for transportation	Promotion of camel milk on television and radio. Introduce refrigerated milk transport vehicles. Construction of milk sales sheds. Support camel milk producer groups
Increased temperatures	Browse and pasture scarcity. Increased water needs for animals. Difficulty in accessing extension and veterinary services due to animals moving in search of water. Reduced breeding	Reduced milk production. More time spent tracking animals which have moved in search of fodder. Difficulty in managing livestock health. Low breeding success. Cannot vaccinate or deworm animals that are weak from heat stress	Reduced milk quantity and quality. Increased perishability of milk. Difficulty in collecting milk for bulking. High cost and time for transportation of milk. Heat and pressure build up in milk containers (resulting in bursting and leaking)	Reduced access to market information. Inconsistent milk supply. Low prices for farmers
Magnitude of impact	Moderate	Moderate	Moderate	Moderate
Farmers' current strategies to cope with the risks	Movement of animals in search of water. Inbreeding	General livestock health management – deworming and hoof trimming)	Awareness raising on milk hygiene. Milk collection and sales using jericans. Consumption of milk at household level	Group sales and marketing. Using motorbikes to transport milk
Other potential options to increase farmers' adaptive capacity	Capacity building on grazing land management. Regulate animal movement to reduce spread of disease	Training on improved herd health management. Tree planting for shade	Use of aluminium containers for transportation. Capacity building on milk handling and distribution of modern milk handling equipment. Construction of milk collection and cold storage facilities along strategic livestock routes	Promotion of camel milk on television and radio. Introduce refrigerated milk transport vehicles. Construction of milk sales sheds. Support camel milk producer groups. Promotion of refrigerated milk transportation

Policies and Programmes

According to the National Government Coordination Several national and local policies and programmes have been developed to address climatic and broader vulnerabilities of the population in Mandera County.

The Arid and Semi-arid Lands (ASALs) Policy of 2007 recognizes that the arid and semi-arid lands are important and require development since they make up 90% of the country and approximately 70% of the national livestock herd. It also recognizes pastoralism as the principal livelihood system in the ASALs. Therefore the goal of the policy is to facilitate and fast-track development in northern Kenya (including Mandera County) and other arid lands by increasing investments in the region.

Subsequent policies which build on the ASALs policy include the National Livestock Policy of 2008 which seeks to address the challenges in the livestock sub-sector in the context of livestock breeding, nutrition and feeding, disease control, value addition and marketing, and research and extension. In Mandera County the Department of Livestock has supported mass livestock vaccination, conducting destocking programmes, implementing water access programmes and supporting fodder production and conservation. Projects such as the USAID-funded Kenya Drylands Livestock Development Program (KDLDP) have been supporting livestock trade and marketing in partnership with organisations such as The Mandera Livestock Marketing Association. However low literacy levels, overstocking, high poverty levels and the wanton cutting of trees are some of the challenges facing the implementation of this policy in Mandera County.

The National Irrigation Policy of 2012 aims to expand the areas under irrigation by opening new lands for irrigation, physical expansion and rehabilitating the existing areas. This is intended to increase the production, productivity and diversification of agricultural enterprises and hence increase food security. The policy is implemented in the county by the County Directorate of Irrigation through the promotion of irrigated agriculture along River Daua. Irrigation development and revival of dilapidated irrigation schemes (such as the Malka Suftu Irrigation Scheme) is meant to support the growing of various crops and fruits including water melon, maize, tomatoes, lemons, oranges, mangoes, bananas and paw paw among others. The development of irrigation is to be complemented by the establishment of large plantations and construction of fruit processing facilities for value addition. However, irrigation is challenged by water scarcity and high cost of irrigation infrastructure and equipment. (GoK, 2015)

The Kenya Forest Policy of 2015 seeks to increase and maintain the tree and forest cover of at least 10% of the land area and enhance the management of forest resources for conservation of soil, water biodiversity and environmental stability. The ASALs offer the greatest potential for afforestation through dryland forests towards achieving the national objective of 10% forest cover. Dryland forests have the potential to supply marketable commodities (such as gums, resins, charcoal) on sustainable basis to improve the livelihoods of the people. KFS in Mandera promotes some of the activities such as tree planting. However rampant tree cutting for charcoal burning by the community and the communal ownership of land challenge the achievement of the policy objectives.

The Agricultural Sector Development Strategy (ASDS) of 2010 aims at increasing agricultural productivity and income growth especially among the smallholders, food security, commercialization and intensification of production among the small-scale farmers. Droughts and floods have increased in frequency causing massive crop failures. This policy is implemented through the promotion of drought tolerant crops such as sorghum and promotion of high value crops such as tomatoes, onions and watermelons along the river basin. The communal land tenure system in the county does not favour implementation of this policy.

In as much as most of the policies enforced in Mandera County are those made at the national level, several programs in the county have operationalized the policies and bolstered the residents against climate change. An example of these programmes is the Kenya Livestock Insurance Program (KLIP). In this program, the government purchases insurance against drought for livestock from private insurance companies on behalf of vulnerable pastoralists. This program was initiated in 2015 for 5,000 pastoralists in Turkana and Wajir as pilot sites. It has now been rolled out in Mandera County where farmers are set to be insured for five tropical livestock units (TLU), which is equivalent to five cattle or 50 goats, with an insured value of KES70, 000. Any additional animals are insured at the expense of the owners. The program is funded by the National government at no cost for herders registered under the Hunger Safety Net Program and. The program is supported by the World Bank in partnership with ILRI.

Asset creation programmes supported by the World Food Programme (WFP) since 2010, is another strategy that is being implemented by the NDMA to increase the adaptive capacity of pastoralists and farmers in Mandera County. The program entails engaging communities in construction of infrastructure for water harnessing such as canals for irrigation, water pans, underground water tanks, and control galleys in exchange for food. These assets are meant to assist their livelihoods since they help them cope with adverse effects of climate hazards. Almost similar to the asset creation program, the Food for Assets program is implemented by COCOP in 81 sites across Mandera

County. This revolves around the community undertaking projects in exchange for food (a type of food for work programme). The programme is strategically designed so that it not only provides for food for vulnerable households but so that the work conducted contributes to long term resilience and adaptation measures such as construction of water canals for irrigation, water pans, pasture production and tree planting. There is also a supplementary feeding program for malnourished children below 5 years of age, and pregnant and lactating mothers. This is an initiative by the Ministry of Health with support from the Save the Child Fund and the European Commission (EC). So far this program has benefited about 41,550 households in the county. However, such initiatives need to be linked well with longer term development and resilience building initiatives in the county.

The UK Government's Department for International Development (DFID) collaborating with the NDMA has also supported the Hunger Safety Net Program where cash is transferred to vulnerable groups in the four poorest arid counties of Kenya, including Mandera, as a way of improving livelihoods. Cash transfers have not only been seen as an emergency response measure for the most vulnerable households but also as a means of allowing households to invest in resilience building assets such as livestock.

In June 2017, in response to prolonged drought in parts of Kenya, FAO and The Kenya Red Cross (KRC) availed a US$690,000 project titled "Emergency livelihood response to support drought-affected households" funded by the UN's Central Emergency Response Fund (CERF) to be implemented in 6 counties including Mandera. The project will provide livestock feed inputs and veterinary, animal health services, animal feed, destocking services, cash based support; and drought-tolerant fodder to vulnerable households. The programme will support households still affected by drought or struggling to transition from drought in the country.
The Regional Pastoral Livelihoods Resilience Project (RPLRP) which commenced in 2015 is a World Bank supported project whose objectives are to enhance livelihood resilience of the pastoral and agro-pastoral communities in cross-border drought prone areas of Kenya, Ethiopia and Uganda and to improve the capacity of the respective governments to respond promptly and effectively to an eligible crisis or emergency. The project has five components namely; natural resources management, market access and trade, livelihoods support, pastoral risk management, project management and institutional support. The project is set to improve livestock markets, enhance animal health services and ensure access to financial services for pastoralists.

In addition to the above-mentioned programs, there is the IGAD-FAO Partnership Programme on Drought Resilience. The IGAD-FAO Partnership Programme and its actions are firmly grounded in the Nairobi Heads of Summit (2011) where IGAD was mandated to take the lead on resilience in the Horn of Africa. This programme seeks to enhance the resilience of communities in selected cross-border locations of Ethiopia (Liben), Kenya (Mandera) and Somalia (Gedo). The five year project is funded by the Swiss Agency for Development Corporation (SADC) with a budget of USD 10 million over 5 years and will be jointly managed and implemented by FAO and IGAD. The program's thematic areas of focus include; trans-boundary animal health control, cross-border marketing and trade, natural resource management and cross-cutting areas of work such as cross-border conflict, gender and nutrition.

A major development that is meant to ease access of pastoralists and agro pastoralists in Mandera County to input and output markets is the paving of the road from Mandera to Nairobi, part of the government's plans to open up the north-eastern part of Kenya. The project is to be funded by a loan from the World Bank. The paved road will be more resilient to flooding and extreme rainfall thus enabling improved and more efficient transport of produce to markets. The road project will also be combined with improvements in telecommunications and internet networks in the county which will also allow for improved market information as well as improved dissemination of information on hazards such as droughts and floods.

The policy and programming environment in Mandera County still needs to improve, particularly regarding better integration of long term resilience building and climate change adaptation measures as opposed to short term coping and response measures. Many national policies exist related to adaptation and resilience. However more needs to be done to ensure implementation and local level adoption of such policies in the county. The national polices can be used as a means to inform formulation of local level policies, strategies and programmes that precisely respond to the specific needs in the county. Of particular importance is the need to build the capacity of various stakeholders especially those in government institutions in implementation of various county level policies and programmes related to adaptation and resilience.

Despite having policies that are geared towards improving the resilience of the community, weak enforcement mechanisms is a major drawback. Weak regular and proper monitoring and evaluation of the programmes and activities that pertain to management of climate risks in the county compromises achievement of the intended goals, and deprives the stakeholders of crucial information for planning purposes.

Governance, 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.

Government departments include the sector departments of Agriculture, Livestock and Fisheries; KMD, KFS, and the Water and Irrigation Departments. The state parastatals include; NDMA, ASDSP, and NEMA. These state actors provide the coordination, technical input, capacity building and policy direction with regard to the implementation of climate risk management strategies. For example, the NDMA is the coordinator and secretariat of climate risk management activities. This is done through the County Steering Group (CSG), composed of all the relevant stakeholders in climate risk management. The NDMA together with the KMD provide monthly bulletins that act as weather agro weather advisories and early warning information for both farmers and development partners.

International and non-governmental organizations (NGOs) supporting the pastoral communities in Mandera County include; Nomadic Assistance for Peace and Development (NAPAD), Rural Agency for Community Development and Assistance (RACIDA), ACTED, Save the Children, Kenya Red Cross, WFP and FAO. These organizations are involved in increasing the adaptive capacity of the pastoral communities to climate change through capacity building and training on integration of resilience into county programmes and projects, provision of inputs such as seeds, facilitating access to credit, farmer training resilience enhancing practices such as fodder production, irrigation development (including solar water pumping), public health promotion, training of cooperatives as well as advocacy and technical support on matters related to resilience and climate change adaptation. The organizations are also involved in shorter term emergency relief measures such as cash transfers and supplemental feeding programmes. For example, ACTED has worked in Mandera County in providing food and cash voucher transfers as well as livelihood support to 16,866 individual. In addition, ACTED also works with communities to develop and implement their Community Disaster Management Plans together with NDMA. These organisations represent a key pillar of the work in the county, however more needs to be done to build the capacity of local actors and institutions on climate risk management for long term sustainability of the initiatives.

With the county being predominantly Muslim, the Islamic Relief Foundation is a key player in the implementation of climate risk management activities. Islamic Relief has also worked with private sector organisation such as SunCulture to provide solar powered irrigation kits to households in Mandera County.

Regional organisations such as The Intergovernmental Authority for Development (IGAD) and their specialised institutions particularly The IGAD Climate Predictions and Applications Centre (ICPAC) and the IGAD Centre For Pastoral Areas And Livestock Development (ICPALD) also have a crucial role to play in terms of supporting access to timely agro weather advisories and development of livestock value chains in Mandera.

Factors that hamper delivery of climate risk management initiatives by these organisations, among others include limited financial, technical and human resource capacity. For instance, most county government departments are insufficiently staffed impairing the implementation and monitoring of activities such as irrigation, tree planting and water harvesting. A good example, are the irrigation schemes such as Hareri Hosle and Shantoley that have for one reason or another failed and required heavy investment for rehabilitation. While coordinating mechanisms such as, the County Steering Group (CSG) exist, with the absence of county-specific policies, there are still weak linkages among the various organisations conducting resilience related work in the county. This is compounded by not having any resilience or climate change focused coordination platform.

As for the international organizations, while they are an important channel for directing funding for resilience initiatives into Mandera County, they too are subject to funding challenges and priorities at organisational level. More could also be done to facilitate partnerships on resilience initiatives between regional organisations such as ICPALD and ICPAC and organisations based in the county.

Synthesis and Outlook

Mandera County is one of the driest County's in Kenya with frequent occurrence of droughts, flash floods and heat waves which all contribute to low agricultural productivity. The climate outlook for the county indicates increased frequency and severity of dry spells, heat stress and intense rainfall events as well as continued changes in the onset and duration of seasons. As a result greater focus will need to be

placed on adaptation and resilience investments for both crops and livestock. Hazards in the County are however compounded by the characteristically low quality of life, high poverty levels, low literacy levels, poor access to fundamental social amenities, poor transport network and high levels of insecurity. These factors combine to make pastoralists and agro pastoralists in Mandera highly vulnerable to weather variability and climate change.

The need for concerted efforts in increasing the provision and access to basic amenities such as water, electricity, education and health cannot be challenged even in the absence of climate hazards. For instance, supporting the few Sharia compliant financial institutions that offer credit services to pastoralists and farmers to engage in more productive agriculture and other income generating activities, and establishment of such institutions encouraged in accessible points throughout the county. While the County government includes promotion of private sector development through Sharia compliant trade finance, commercially oriented cooperatives, and enterprise development, there is need to have a clear private sector strategy for the County particularly with regards to irrigation development, processing of agricultural produce, micro-finance for resilience investments and clean energy among others.

Limited accessibility across the County due to poor road networks and communication infrastructure are areas which require continued attention. Investments in an improved road network in the County is vital in opening up the vast county to investment opportunities as well as allowing for improved access to input and output markets. This should be conducted in tandem with developing appropriate market infrastructure for (cold) storage, processing, value addition and sales of livestock and other agricultural commodities.

Efforts to enhance the resilience of farmers and pastoralists have focused on irrigation development, access to water, fodder production and animal health management. Efforts have been made to intensify irrigation and make it more efficient through drip irrigation and solar irrigation but there is still greater potential that has not been harnessed, while the maintenance of irrigation infrastructure is an aspect that needs greater attention. Introduction of drought tolerant crops should be encouraged to diversify the agricultural enterprises and supplement livestock production to increase the adaptive capacity. Continued capacity building on simple water and soil conservation measures such as conservation agriculture and zai pits needs to continue particularly for resource poor farmers without sufficient resources for more capital-intensive adaptation investments.
Early warning systems are a key component in addressing climate change hazards. However, the capacity of KMD to collect and disseminate timely and reliable weather information is hampered by the vastness of the county. Provision of automated weather stations in the county will enhance precision and accession of weather information in the county. Weather forecasting should also involve and borrow from indigenous knowledge mechanisms such as the use of the local community weather forecasters for predicting weather events as this can improve the rather low utilization of the provisional weather information from the weatherman.

With the perennial incidences of drought occurrences in Mandera County, there is an urgent need to augment the collaboration of the multiple stakeholders and institutional capacity to respond to these hazards. Policies at county level with regard to climate change need to be drafted and mainstreamed in county plans. This will ensure engagement of all stakeholders in a coordinated manner and ensure that there is a coherent financing mechanism. Ensuring relevant capacity in government departments and among development partners to implement and monitor resilience initiatives will also be imperative.

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