Climate Risk Profile
Lamu County

Highlights

- Agriculture is a vital sector in Lamu County, contributing approximately 90 percent of household incomes, however production is mostly small scale, on an average of four (4) ha land holdings and highly dependent on rain fed agriculture. Only 24 percent of the farmers have title deeds, and this limits investments on land and access to services like credit.
- Delayed and erratic rains have led to a decline in productivity with extended droughts culminating in crop losses, scarcity of fodder and destruction of inshore fish breeding grounds.
- Poor road infrastructure have led to high input costs as well as poor access to inputs, markets, and extension services. Recent security challenges have interfered with agriculture extension activities, night fishing, and marketing of agricultural products reducing farmer resilience to hazards.
- Crop related adaptation strategies include use of drought-tolerant varieties, fast-maturing crop varieties, establishing local nurseries, conservation agriculture and irrigation using river water, shallow wells, and water pans, although the low-lying flat land and sandy soils constrain irrigation initiatives. Contract farming should be promoted more vigorously to ensure farmers have ready buyers for their produce. This could also aid in access to finance and inputs. Establishment of local packaging and processing facilities as well as continued capacity building of farmers would also be crucial for long-term resilience building.
- Fishing in breeding zones to catch the smaller fish is a common coping strategy, while use of ice and sun drying for preservation of fish during sales and marketing are also practiced. Longer term strategies should involve development of large fish processing and cold storage facilities and financial and technical capacity building of fishers on cage culture (for example for prawns) and fish value addition. Deep-sea fishing has become necessary due to high high competition and dwindling near shore fish stocks.
- In chicken production, common coping strategies include home feed production, allowing free ranging, home slaughter and consumption, and group marketing. More needs to be done to improve slaughterhouses and chicken processing facilities, while also developing cold storage facilities.
- Farmer coping strategies and adaptation efforts are bolstered by County government support towards extension, seed provision, access to weather information and community irrigation projects. The National Drought Management Authority (NDMA) coordinates and provides early warning information for use by different agencies and government departments. The County government, Northern Rangelands Trust (NRT), and World Wide Fund for Nature (WWF) have elaborate capacity building initiatives that promote sustainable and conservative use of terrestrial and marine resources. The county government revolving fund is helping fishermen to acquire bigger boats with bigger engines to be able to venture into deep-sea fishing.
- The role of the National Environmental Management Authority (NEMA) and the Kenya Meteorological Department (KMD) has not been strongly realised in the county. Additionally, the Agricultural Sector Development Support Programme (ASDSP) through the Participatory Scenario Planning (PSP) project has not fully taken off. These stakeholders and programme are instrumental in climate resilience and their work needs to be supported.

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

List of acronyms

A.S.L	Above Sea Level
AEZ	Agro-ecological zones
AFD	Agence Française de Dévelopement
AI	Artificial Insemination
ASDSP	Agricultural Sector Development Support Programme
BMU	Beach Management Unit
CCPP	Contagious Bovine Pneumonia, Contagious Caprine Pleuropneumonia
PPR	Peste des Petits Ruminants
CDF	County Development Fund
CMDRR	Community Managed Disaster Risk Reduction
DANIDA	Danish International Development Agency
ECF	East Coast Fever
ERA	Economic Review of Agriculture
FMD	Foot and Mouth Disease
GoK	Government of Kenya
IPCC	Intergovernmental Panel on Climate Change
KALRO	Kenya Agricultural and Livestock Research Organization
KCSAP	Kenya Climate-Smart Agriculture Project
KES	Kenya Shillings
KFS	Kenya Forestry Service
KMD	Kenya Meteorological Department
KNBS	Kenya National Bureau of Statistics
KRDP	Kenya Rural Development Program
KWS	Kenya Wildlife Service
LSD	Lumpy skin disease
MT	Metric tons
NCCAP	National Climate Change Action Plan
NCCRS	National Climate Change Response Strategy
NDMA	National Drought Management Authority
NEMA	National Environment Management Authority
NGO	Non-governmental Organization
NRT	Northern Rangelands Trust
PSP	Participatory Scenario Planning
SMS	Short Message Service
TIMPs	Technologies, Innovations and Management Practices
VCC	Value Chain Commodity
WARMA	Water Resources Management Authority
WWF	World Wide Fund for Nature

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 Lamu County with a climate vulnerability index of 0.159[1]. Despite the low vulnerability, Lamu has suffered several extreme weather events including dry spells, floods and high temperatures, which have put livelihoods of the people at risk. Assessment of historic climate data shows that there has been a significant change in the climate in the county over the last 35 years, where precipitation has increased, with more variability, and temperatures in the Indian Ocean increasing by 0.2°C per decade. The climate variation has contributed to food insecurity where for instance in 2016 approximately 40 percent of the children below 5 years were malnourished due to poor agricultural production, and impaired fishing, scarcity of water, and livestock deaths. There has been a remarkable decline production of sorghum, sesame, and maize, attributable to the climate variation. For instance, maize production has reduced from 7-8 bags per acre in the early 1990s to 2-3 bags[2] per acre at present. The 2017 drought left more than 50,000 residents and approximately 300,000 livestock at the verge of starvation[3], whereas some areas namely Bonini, Kiunga and Merina in Lamu East experienced floods that displaced about 500 families[4], In response to the effects of extreme weather events, a number of interventions including provision of food relief, promotion of Vitamin A and Zinc supplementation and promotion of drought-tolerant crop varieties have been implemented. Increasing the scale of the current resilience-related technologies and interventions while addressing institutional weaknesses that hinder their adoption will go a long way in ensuring sustainable livelihoods in the face of climate variation and change.

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; WFP (2013).
2 http://kulima.com/wp-content/uploads/2011/03/Climate-Vulnerability-and-Capacity-Analysis-of-the-Lamu-Sea-Landscape.pdf
3 http://www.nation.co.ke/counties/lamu/Lamu-cancels-food-expo/3444912-3820120-format-xhtml-12i00qdz/index.html
4 http://www.the-star.co.ke/news/2017/05/19/lamu-families-left-in-the-cold-after-floods-sweep-away-homes_c1563679

Agricultural context

Economic relevance of farming

Lamu County is one of the six coastal counties in Kenya. It borders Somalia on the northeast, Garissa to the north and the Indian Ocean to the south. The county is composed of the mainland and 65 islands forming the Lamu archipelago. The land is generally low-lying and flat with the highest level being 50 m above sea level (a.s.l). Agriculture is a key sector of the Lamu economy, contributing 90 percent of the total household incomes. The key sub-sectors under the agriculture sector are crops, livestock, and fisheries (GoK, 2017a). The main crops grown are maize, cowpeas, dolichos, cassava, pigeon peas, and green grams. Mangoes, coconut, cotton, bixa, and simsim are produced for commercial purposes. Cotton is the most important commercial crop in the county, contributing 42 percent of the household income. Cattle, sheep, goat and poultry are the most common livestock reared in this county. Thirty percent of the county's population depends on livestock directly or indirectly (GOK, 2017b). Fishing is also an important economic activity in the county providing food and employment; engaging 3,500 artisan fishermen (GoK, 2017b).

People and livelihoods

According to the Kenya National Bureau of Statistics, (KNBS), Lamu had a population of 101,539 in 2009. Males and females constitute 52 percent (53,045) and 48 percent (48,494) of the population respectively. This population is projected to reach 137,180 by 2017, with males constituting 52 percent (71,664) and females 65,515 (48%). Lamu the only urban center in the county had a population of 16,833; half were females. The statistics projected urban population in the county to increase to 21,994 in 2017 with 11,062 males and 10,932 females. Eighty-three percent of the population live in rural areas. It is estimated that 32 percent of the total Lamu population are poor (GoK, 2015). The poverty levels are higher in the urban areas (45 percent) and comparatively low in the rural areas 29 percent (GoK, 2017a). In 2016, approximately 60 percent of the population of Lamu West and 66 percent of that of Lamu East needed food assistance (GoK, 2017a). Approximately 64 percent of the male-headed households were food insecure compared to 11 percent of the female- headed households. Amongst the children in Lamu, 29 percent are stunted while 4.2 percent were wasted (GoK, 2014b).

The county's main sources of water are groundwater, surface water, rain water, and desalinized seawater. Most of the places have saline underground water. Fifty-five percent of the population have access to clean drinking water. Households that have access to piped water account for 31 percent of the population of the county. Seventeen percent of the population use electricity for lighting while 72 percent use paraffin. The main sources of cooking fuels are firewood and charcoal, electricity, gas (LPG) and paraffin. Firewood and charcoal is used by 71 percent of the population (GoK, 2017a). The county has a literacy level of 67 percent. It has a 92 percent pre-school enrolment rate compared to the national average of 72 percent. Gross enrollment rates in primary and secondary schools are 75 and 43 percent respectively. The transition rate from primary to secondary school is 73 percent while the secondary school completion rate is 94 percent (GoK, 2017a).

Economic activities of the county hinge around agriculture, livestock, fisheries, forestry, mining, and tourism. Agriculture is the main sector, engaging 73 percent of the population. The livestock sector is also key, as it is a means of livelihoods for about 30 percent of the population. The county benefits greatly from the Indian Ocean, which supports about 75 percent of the county's fishing, estimated to yield 1500 MT per year. The key tourist attraction areas are the Boni-Dodori national reserve, Kiunga Marine reserve, Takwa and Pate ruins, the Maulid, and Lamu cultural festivals. The Bajuni and Boni people depend on the forest as a source of food; they also sell honey and other wood products. Forty-five percent of the population's labour force is in the informal sector while 15 percent is in the formal Sector. Sixty-five and 88 percent of the males and females are actively involved in economic activities of the county.

Agricultural activities

The total land area of Lamu County is 6273.1 km^2 (627,310 ha) of which 5,517 km^2 (551,700 ha) is arable and 308 km^2 (30,800 ha) is under water mass. Thus, over 80 percent of the land in Lamu is arable and can be used for agricultural purposes (GoK, 2014a and GoK, 2017a). Forests cover about 12 percent of the land. Gazetted forests include the mangroves and Witu Forest while non-gazetted ones are Lunge, Boni Forests and Lake Kenyatta buffer zone. Of the total arable land, 56,923 ha is being utilised; 21,311 ha is under food crops, 22,476 ha under cash crops, and 13,136 ha is under farm forest (GoK, 2017a). Lamu County is amongst the coastal counties that are

experiencing land ownership problems. A big portion of land is not registered and is held under ancestral ownership; only 20 percent of the farmers have title deeds (GoK, 2017b).

The main agricultural areas are Mpeketoni, Witu, and Hindi Divisions. In these areas, the average land ownership is 10 ha. However, the average land size in the whole county is 4ha per household. The main food crops produced are maize, cowpeas, grams (green and black), finger millet, cassava, and pigeon peas. The county also produces mangoes, coconut, cotton, bixa and simsim as cash crops. Cotton has much potential and is the highest income earner amongst the cash crops, contributing 42 percent to household incomes. Those living in the Lamu peri-urban areas practice subsistence farming (GoK, 2014a).

Livestock production is another important component of agriculture; the most popular animals reared are cattle, sheep, goats, donkeys and poultry. Most of the livestock are produced under small-scale production. There are 20 ranches in the county, 5 covering 65620 ha are operational, 7 covering 81,420 are non-operational, 3 of 56,000 ha are idle, and 5 equivalent to 56,000 ha are proposed. These ranches act as grazing reserves and are used by pastoral farmers from Lamu County as well as from the neighbouring Garissa County. Fishing is the main economic activity for the
residents of the Island. There are approximately 40 fishing grounds in the county with a rich diversity of fish species; with a potential of about 1,500 metric tons of fish per annum. However, the current production is low due to factors such as lack of fishing equipment. The county fisheries department is introducing cage fish farming to increase catches and foster sustainability.

Most of the farming in Lamu is rain-fed; approximately one percent of the households undertakes irrigation farming. The main areas where irrigation is practiced are Zebra, Sina mbio, Mpeketoni, and around the Tana Delta. The use of fertiliser is still low in this county. According to the Agriculture Sector Development Support Programme (ASDSP) 7 and 9 percent of the farmers use basal chemical fertiliser and manure during the first and the second season respectively. Approximately 10 percent of the farmers used top dressing fertiliser in the first season and 16 percent in the second season. Ten percent of the farmers use herbicides in both seasons. In the first season 31 percent use field pesticides, this proportion is much higher in the second season at 57 percent. A considerable proportion of the farmers, 31 percent in season 1 and 28 percent in season two, used postharvest pesticides mainly for storage. Input use is higher in season two compared to season one (GoK, 2014a).

Agricultural value chain commodities

A broad diversity of agricultural commodities are grown in the county. Of these, various value chains have been prioritised 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 (VCCs) were selected for in-depth analysis based on: prioritization in county frameworks and programmes; economic value (KES/bag or KES/livestock or KES/unit livestock product)[5]; resilience to current weather variability and future climate change[6]; and number of economically active people engaged in the commodity's value chain (including vulnerable groups, women, youth, and the poor[7]). The VCCs selected are cotton, cashew nuts, local chicken, and fish.

Cotton

Cotton is an important cash crop for Lamu County as it contributes 42 percent of household income. The crop is mainly produced in Lamu West and a few areas in Lamu East. In Lamu West, production is in Witu, Mkunumbi, Hongwe, and Bahari while in Lamu East it is grown in Kidurunu area of Basuba. Small-scale, commercial rain-fed system of 0-2 ha is the main production system either as a pure stand or in mixture with another crop. Such systems exist in all the cotton-growing areas in Lamu West. In Lamu East, the farmers practice the pure stand production system. Despite most of the crop being produced in Lamu West, there is potential for increased production in Lamu East as well. The land under cotton production has been varying over time. A total of 6,849; 7,922; 2,944; 5,159; and 5,170 ha were under cotton cultivation in 2011, 2012, 2013, 2014 and 2015 respectively. Yields have also varied over time; in 2011, the average yield

5 As stated in the 2015 Economic Review of Agriculture (ERA)

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

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

Livelihoods and agriculture in Lamu

Demographics

0.3% Of Kenya´s population

399,227 inhabitants

83% Live in rural areas

48% 52%

Access to basic needs

32% of the population lives in **absolute poverty**

Potable water	55%
Electricity for cooking	ND
Electricity for lighting	17%
Education (youth literacy rate)	ND

Food security

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

ND of household **income spent on food**

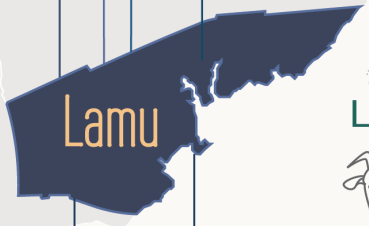
ND People **undernourished**

29% Children **stunted**

4% Children **wasted**

ND: No data

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



Farming

County´s farming area 5,517km² 85%

73% of the population employed in agriculture production

20% 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

7% Planting fertiliser

10% Top dress fertiliser

Pesticide types (% of households)

45% Field pesticides

31% Storage Pesticides

10% Herbicide

was 0.28 Mt/ha. It has increased steadily to 1.5 Mt/ha in 2015; and was valued at KES 325,710,000.

The main actors in the cotton value chain are farmers, the government, farm input suppliers, casual labourers, and ginners. Farmers are the producers who source seed and extension services from the county government. The national government supplies seeds through the county government. The crop uses much casual labour in land preparation, spraying, and harvesting. Input suppliers supply pesticides and other inputs to farmers. Cotton production requires high amounts of field pesticides to protect the crop against pests. Farmer groups and the cooperative bulk the cotton and sell it to ginners. One of the important cooperative is Lake Kenyatta Cooperative Society. The ginners that buy cotton from Lamu are Kitui, Malindi, Mezu, Mpeketoni, and Makueni ginnery.

Cashew nuts

Cashew nut is grown in both Lamu East and Lamu West. Over 60 percent of the farmers in the county have cashew nut trees on their farms on small scale. The main varieties produced are A41, A47A, A75-83, A81, and A100. The main production systems are small-scale mixed commercial, small-scale mixed subsistence, and large-scale mixed commercial. Small-scale mixed commercial farming is undertaken in areas of Witu, Hongwe, Bahari, Mkunumbi, Faza, Bodhei and Majengo in Basuba, and Mangai in Kiunga. On the other hand, small-scale mixed subsistence production is found in the areas of Hindi and Mkomani while large-scale commercial production is practised in Kiduruni of Basuba. The land under cashew nut production increased from 4,126 ha in 2011 to 7,223 ha in 2015. Yields have been fluctuating over the past five years. Production was 0.73Mt per ha in 2011 increased to 1.88 Mt per ha in 2012, but decreased to 1.08 Mt per ha in 2014. The county produced cashew nuts worth KES 412,185,000 in 2015.

Cashew nut production involves adult males and females, and the youth. Individual nursery owners who are mostly medium scale produce the seedlings. KALRO is the other key supplier of seedlings. Extension services to farmers are provided by the Department of Agriculture and by other farmers through farmer groups. The farmers use their family and casual labour for the on-farm production activities and harvesting. Suppliers of agricultural inputs play an important role of supplying chemical and other inputs. Currently, farmers do not use sufficient pesticides for cashew nut production in the county. This has sometimes compromised the quality and production levels. The main buyers of the crop are cooperatives and local traders. Small cottage processors process some.

Chicken (local)

Local chicken are reared across Lamu County. The local chicken value chain is considered pro-poor and supports youth and women. The farmers are categorized as small scale, medium scale, and large scale. The key production systems are free range, deep litter, and run system. The most popular systems are small-scale free range and medium scale run systems that are spread all over the county. The small-scale deep litter system is practiced in a small area in Hindi, bordering Manda Airport while the large-scale run system is undertaken by some farmers in Mkomani. Local chicken require little feed and inexpensive housing. It is one of the value chains that is supported by the ASDSP because of its potential to eradicate poverty amongst the poor. A survey conducted by the Lamu County Department of Livestock found that on average, a household keeps 17 chickens. There has been an increasing trend in the population of indigenous chicken, increasing from 122,243 birds in 2010 to 310,760 by 2016. With a market price of approximately KES 600 per bird, they were estimated to be worth KES 186,456,000 in 2016 and eggs production worth KES 9,000,000 most of which were for home consumption.
The county government Department of Livestock and Veterinary Services provides veterinary and extension services. The enterprise also utilises local casual labour in the on-farm production processes like feeding, hygiene and cleaning, slaughtering, and dressing. Input suppliers provide feed drugs and building material to farmers. The farmers hatch their own chicks but there are also some small-scale chick breeders. Jua Kali artisans build chicken housing for the farmers. The chicken are sold in the local markets with the main buyers being home consumers, hotels, and restaurants.

Fish

Fish is an important value chain for Lamu County and is divided into marine and inland freshwater fishing. Marine fishing accounts for 75 percent of the total fish volumes while inland fishing accounts for the remaining 25 percent. Marine fishing involves harvesting fish from the ocean and creeks/channels while inland fishing is done in inland water bodies like riverine systems, permanent or seasonal lakes and ponds. Aquaculture is practiced around Hongwe Bahari, parts of Mkunumbi, Hindi, and Mangai. Small-scale sea fishing is undertaken along the shores of the ocean. Tuna fish is caught in the deep seas while prawns are harvested in the channels. The Department of Fisheries data reveal fluctuations in the quantities of fish harvested in Lamu County in the last five years. In 2010, 2.39 million kg were harvested. The quantity declined to 2 million kg in 2012 and rose to 2.26

million kg in 2014. The revenue realised increased steadily over the same period from KES 169,134,271 in 2010 to KES 354,141,141 in 2014.

The fish value chain involves boat owners, fishermen, boat makers and repairers, input suppliers, fish dealers and mongers, the Department of Fisheries, NGOs, and the Beach Management Units (BMU). The BMU is an association of the value chain actors and stakeholders that help self-regulate the fisheries value chain. The key input suppliers are boat engine suppliers, ice suppliers, and fishing gear suppliers. Service providers include porters, net menders and port makers. The Fisheries Department and NGOs such as Northern Rangelands Trust (NRT) and World Wide Fund for Nature (WWF) provide important extension, advisory, and educative information. Fish caught is sold within Lamu, other cities in the country, and on international markets. The Fisheries Department assists by connecting the fish sellers to local and international markets. Fishmongers undertake fish retail in the local market. The fish value chain cooperatives are currently inactive or have collapsed due to mismanagement.

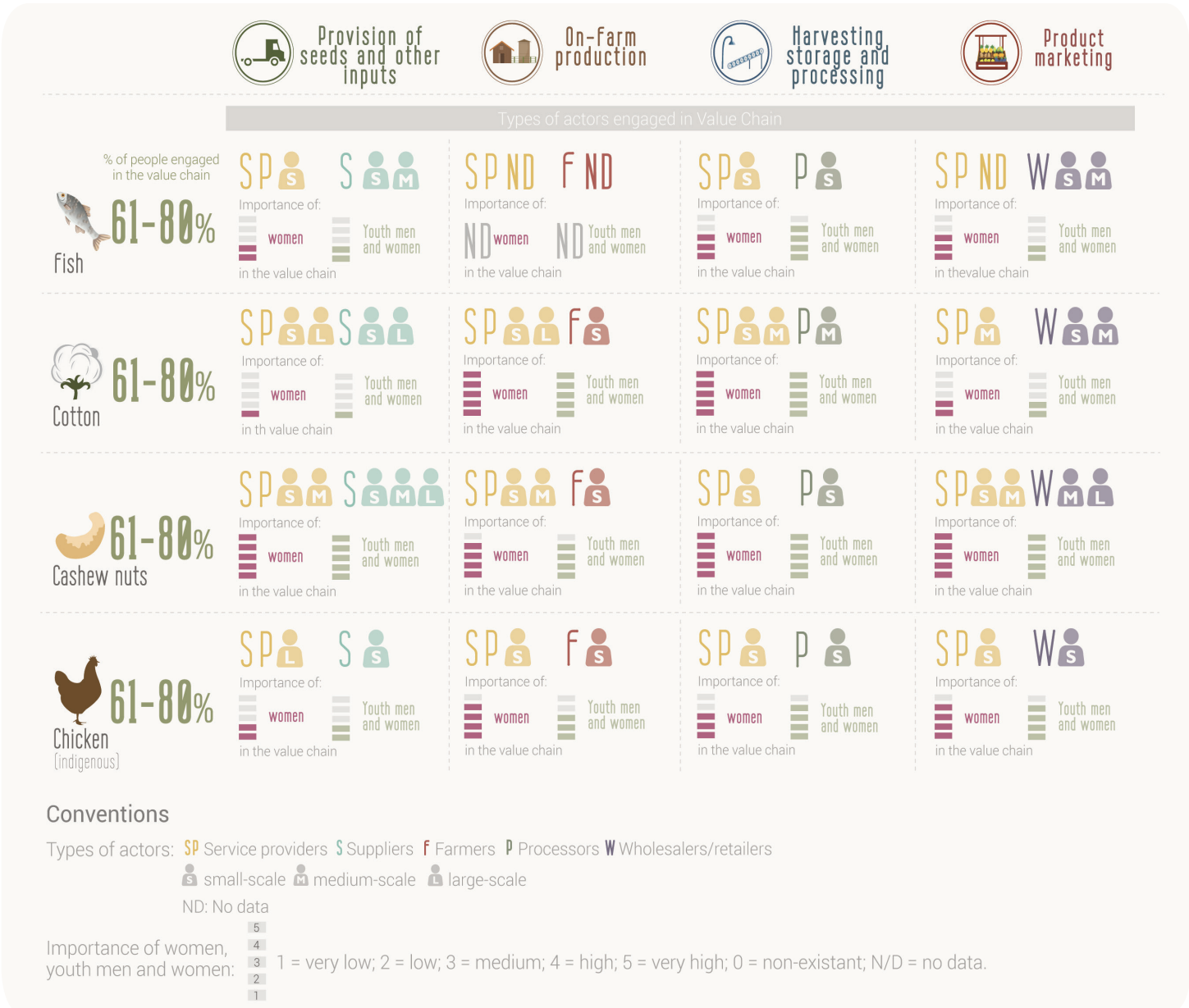
Agricultural sector challenges

The agricultural sector in Lamu suffers many challenges related to production, service provision, and market access. Dwindling and erratic rainfall results in reduced production and in some cases crop failure. It also results in scarcity of pasture and in extreme cases loss of livestock. High temperatures affect the breeding areas of fish, thus reducing quantities in the ocean. Use of irrigation in the county is very low. This is because most places in the county have saline underground water that is not suitable for irrigated agriculture. The topography of the county is also generally flat, making it difficult to use simple gravity-supported irrigation systems. The scarce rains are increasingly resulting in drying of lakes and rivers an example is Lake Kenyatta, whose water volume has decreased significantly over the years. Such reductions affect sources of irrigation water. Farm mechanisation equipment for land preparation and transport is inadequate in the county. The farmers depend on tractors mainly from neighbouring counties. Farmers in Lamu Island lack efficient means to transport their produce from the farm to the markets; they use donkeys, which are slow and inefficient. Post-harvest handling equipment for crops, livestock products, and fish is also inadequate. This results in high postharvest losses.

The availability of the grazing reserves and ranches in the county attracts livestock from neighbouring counties of Garissa and Tana River, sometimes causing resource use conflicts. This increases incidences of Foot and Mouth Disease (FMD), Lumpy skin disease (LSD), Contagious Bovine Pneumonia, Contagious Caprine Pleuropneumonia (CCPP), and Peste des Petits Ruminants (PPR). East Coast Fever (ECF) is introduced by hay infested by ticks that is imported from other counties in the Rift Valley.

Most of the fishermen are poor and depend solely on proceeds from fishing. They also lack a saving culture; thus limited financial ability to cushion them against effects of climate change. Destructive over-fishing and fishing techniques have resulted in dwindling inshore fish stocks. Regarding land tenure, only 24 percent of the farmers in Lamu have title deeds to their land. This limits the level of investment that can be done on the land. The challenges of land ownership coupled with low economic status hinder adoption of new technologies that can increase productivity and enhance market access. Financial and human resources in the agriculture sector in the county is inadequate. Currently the departments have shortages of staff. For instance, the Irrigation Department has only two irrigation officers. Moreover, compared to other Counties Lamu receives a very small allocation from the treasury. This also limits implementation of agricultural projects. Poor road infrastructure and sea transport make transportation of produce and inputs expensive. The whole of Lamu County has only 6 KM of tarmacked road. Sea transport using boats to the islands to deliver inputs and extension services as well as produce to the market is expensive. Due to the county's proximity to the Somali border, insecurity has been high. The ban on night fishing has affected fishermen directly. The insecurity has also reduced the traffic of tourists that created a big demand for local farm produce.

Agricultural value chain commodities in Lamu



Conventions

Types of actors: SP Service providers S Suppliers F Farmers P Processors W Wholesalers/retailers

S small-scale M medium-scale L large-scale

ND: No data

Importance of women, youth men and women: 5 4 3 2 1 1 = very low; 2 = low; 3 = medium; 4 = high; 5 = very high; 0 = non-existant; N/D = no data.

Climate change-related risks and vulnerabilities

Climate change and variability: historic and future trends

Lamu County has a generally hot dry climate. Mean annual temperature are above 25°C in most of the county and mean annual rainfall averages 900mm per year for the county as a whole. The central parts of the county receive the highest rainfall totals sometime averaging over 1000mm per year while the north-eastern parts receive an average of between 500 and 1000mm on average and a pocket in the south receiving lowest average annual rainfall of less than 250mm in some places. Heat stress, dry spells, and drought are hazards that strongly contribute to agricultural risk in the county. Reports have indicated that droughts in the county not only affect crop and livestock production but also other water-reliant activities such as honey production[8] and fishing as well as wildlife[9].

Analysis of temperature trends in the county over 25 years (1981 to 2005), showed that first season mean temperatures have increased by approximately 1°C while second season mean temperatures have increased by 0.5°C. Worryingly, analysis of average annual rainfall, measured over a 35 year period (1981-2015), showed a steeply decreasing trend in first season rainfall although second season rainfall averages have not changed significantly. The increases in temperature and reduction of first season rainfall have resulted in an increase in the number of heat stress days[10] in both seasons along with an increase in drought risk[11].

Climate projections for the period 2021-2065, based on two representative concentration pathways (RCPs[12]), indicate that under both scenarios mean temperatures are expected to continue to increase. Of significance is that under the high emissions scenario the number of days with temperature greater than 35°C rises from less than 20 days historically in the first season to greater than 40 days and from less than 5 days in the second season to approximately 17 days. Although the increases are not as large under the low emissions scenario they are still significant. A major impact of this continued rise in temperatures is an increase in the number of consecutive drought stress days in the first season from approximately 45 days historically to approximately 75 days under the conservative GHG emissions scenario to as much as 80 days in the high emissions scenario. The length of both seasons under the two scenarios is also expected to decrease, both scenarios indicating a reduction of greater than five days in first season length and a backward shift in the start of the second season. Total seasonal precipitation on the other hand is expected to reduce slightly in the first season (≈5%) and increase in the second (≈20%) under the low emissions scenario, while under the high emissions scenario the first season rainfall total remains fairly constant although second season rainfall increases by as much as 35% from the historical average. Peculiarly despite, the increases in temperature both scenarios indicate that there could also be a reduction in days with moisture stress in the county. Overall, although the projections of future climate change under the two GHG emissions scenarios show some differences, both indicate the likelihood of significant changes in the weather and climate of a county already vulnerable to drought, dry spells and heat stress.

Climate Perceptions by the farmers

Crop production, livestock keeping, and fishing are the main agricultural activities in Lamu County. The farmers believe that climate change is as a result of interference/destruction of the environment. The county is experiencing droughts that are more prolonged and a rise in temperatures. There are delays in the onset of rainfall, the rains have decreased and become unpredictable. In 2016, the short rains never came. These weather conditions have resulted in crop failure and reduced yields. Even the yields of drought-tolerant crops like cotton and cashew nuts have decreased drastically. The farmers admit that there are extended droughts that result in decreased crop production and losses. Coconut farmers reported losses of approximately 40 percent. They observed that coconut and cashew nut trees were drying, an occurrence that they had never experienced before.

Depressed rains result in scarcity of fodder, leading to malnourishment and even death of livestock. Increases

8 http://www.nation.co.ke/counties/lamu/Lamu-drought-no-honey/3444912-3833572-rrdmxx/index.html

9 http://www.nation.co.ke/counties/lamu/Salty-ocean-water-kill-wildlife/3444912-3826670-50ixevz/index.html /

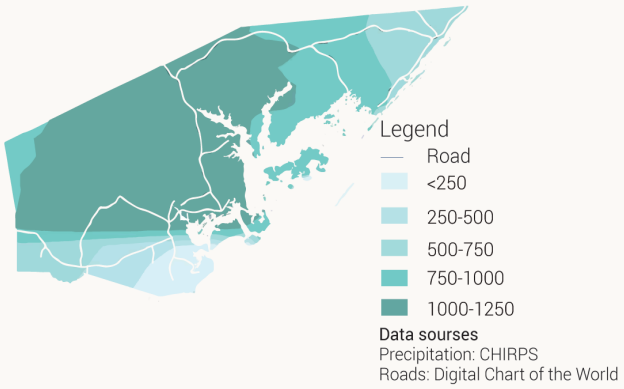
10 Indicated by the number of days with a maximum temperature above 35°C.

11 Days with precipitation less than 1mm per day

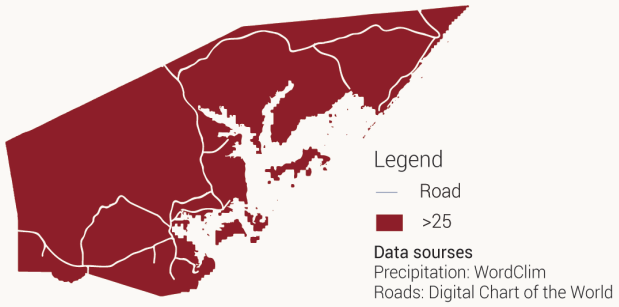
12 The two RCPs, RCP2.6 and RCP8.5, are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6 and +8.5 W/m2, respectively). The pathways are used for climate modelling and research. They describe two possible climate futures, considered possible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

Past and future impacts of climate hazards in Lamu

Historical annual mean precipitation (mm/year)

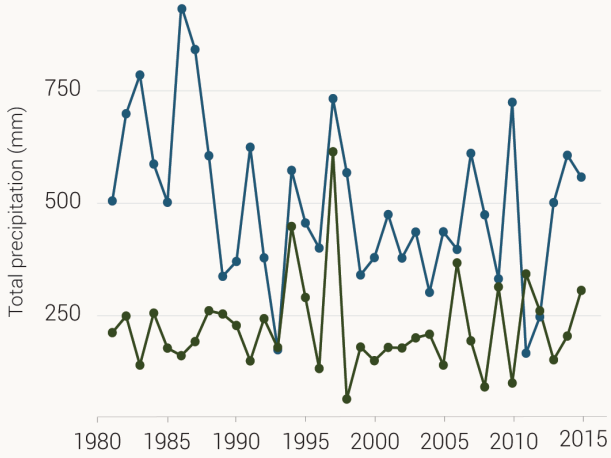


Historical annual mean temperature (°C)

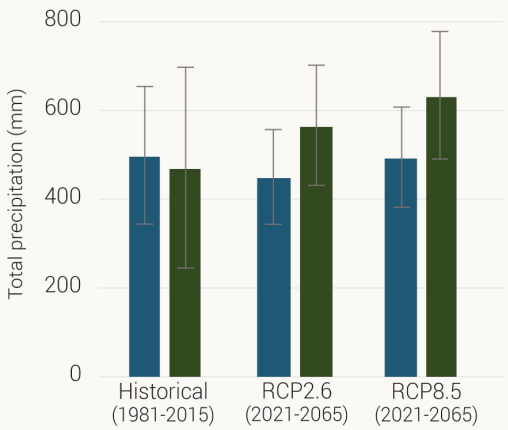


Total precipitation hazards

Historical extreme total precipitation stress events

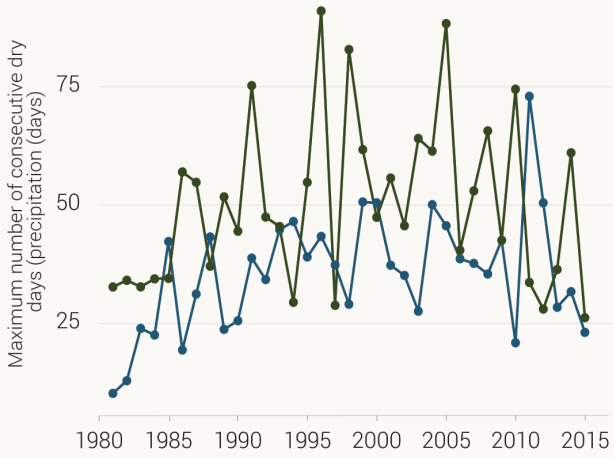


Historical and expected extreme total precipitation stress events

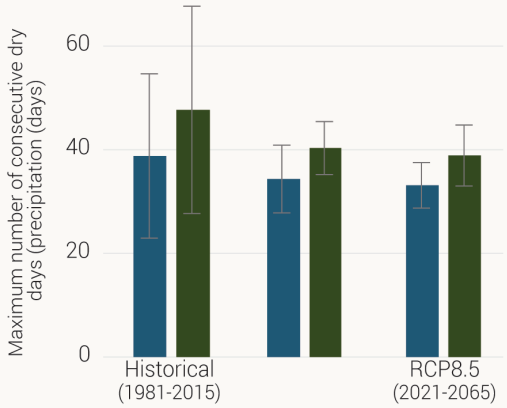


Drought hazards

Historical drought stress events



Historical and expected drought stress events



January - June July - December

in livestock diseases were reported. Movement of livestock coupled with suppressed immunity because of malnourishment increase disease incidences. The most common diseases associated with drought are Foot and Mouth Disease (FMD), Lumpy Skin Disease (LSD), Contagious Bovine Pneumonia, Contagious Caprine Pleuropneumonia (CCPP) and Peste des Petits Ruminants (PPR). During droughts, hay is brought in from other counties in the Rift Valley. The hay is associated with transmission of ticks and hence East Coast fever (ECF) disease. The fishermen have realised that delays in onset of rains interfere with breeding of fish and the fishing season. Rains expected in May delay to as late as July and in addition, they end earlier than expected. This results in shortened fishing seasons. The sea has become rougher than before, which hinders deep-sea fishing and fishing technologies that use fishing lines. The hot season has become longer; this affects fishermen, especially those who fish during the day with boats that do not have shades. The farmers also reported that drought has resulted in drying of shallow wells and increased salinity in other wells.

Climate vulnerabilities across agriculture value chain commodities

The most perilous climate change hazards in Lamu are associated with depressed rains and drought. The key ones that were highlighted by stakeholders in the county are depressed rains, uncertainty in seasons (onset and duration), moisture stress, increase in temperatures, reduction in rainfall, and increase in frequency of droughts. These hazards have profound effects on different stages of the aforementioned value chains as elaborated in the following sections.

Cotton

Cotton is a drought-tolerant crop that requires minimal rains but at the right time. The most desirable species are *Gossypium hirsutum, Gossypium barbadense, G. hirsutum*, and *G. barbadense*. In Lamu, uncertainty in seasons (onset and duration) and moisture stress at the important growing stages are the most threatening hazards. Areas around Bahari, Hindi, parts of Basubu around Kiduruni, and Kiunga were more prone to the threat of uncertainty in seasons (onset and duration). Increased days with moisture stress are likely to be observed in Witu, Hongwe, Bahari, Hindi, and Amu. Uncertainty in seasons has minor effects on procurement of inputs but greatly affects cotton yields. The hazard results in less use of chemicals hence reduced costs of production. However, this poses the threat of the stockist carrying over chemicals from one season to another, which may lead to the danger of selling expired pesticides in the next season. During production, reduction in the length of the season results in poor fruiting hence reduced yields. This leads to underutilisation of storage facilities at farm and bulking level. Cotton is mainly bulked through farmer groups and cooperatives. A small number of cottage industries also uses it. Thus reduced output at farm level leads to less cotton for transportation, cottage industry and bulking. This results in underutilisation of storage and processing facilities. Effects on facilities were considered moderate.

Moisture stress moderately increases use of pesticides. Increased infestation by sucking insects necessitates increased spraying frequency, thus increasing work and costs. However, dry soils provide the best conditions for harvesting the crop. This is a minor relief to the farmers. Post-harvest handling is not affected, as the conditions are highly conducive to preparation, sorting, cleaning, and bulking cotton. However, dry conditions make the soils friable and difficult for farmers with motorcycles to ride on.

Literate farmers who are better off economically are able to address the aforementioned challenges; the most vulnerable are the poor and illiterate farmers. Literate farmers are able to discern expired chemicals, procure pesticides in case of infiltration by pests and use their own or hired vehicles to transport their cotton. The government is providing seeds and extension support. Marketing by the cooperatives and farmer groups is an important initiative that helps the farmers to cope with the situation. The farmers should be allocated enough extension staff to educate them on best agronomic practices. The training should include tillage and land preparation, timing of planting, soil fertility management, crop rotation, and pest and disease control. It is necessary to include lessons on appropriate varieties for disease resistance and other pest control strategies. Cotton production thrives under irrigation. The county should therefore invest in irrigation systems in the end to reduce challenges associated with rain fed production.

Cashew nuts

Cashew nut is a perennial crop that is grown mainly for commercial purposes. The two critical climate change hazards that influence this crop are uncertainty in seasons; early start and decreased length of growing season. Areas around Witu, Hongwe, Bahari, parts of Basuba near Kiduruni and Mangai are the most susceptible to the two hazards mentioned above. Areas around Hindi and Manda Island are more likely to be affected by uncertainty in seasons (onset and duration). Uncertainty in seasons (onset and duration)

finds many input suppliers, service providers, and farmers unprepared. It affects mainly acquisition of seedlings that are not ready for transplanting. Agro dealers will not have stocked fertilisers, and extension services are disoriented. However, these impacts are considered moderate. Land preparation and other initial operations are also affected. Farmers are not ready for land preparation so the demand for casual labour rises sharply, increasing costs. Some farmers therefore engage family labour for land preparation. Unpreparedness results in late planting, which will affect the vigour, hence quality and quantity of yield. Increased incidences of pests and diseases also lead to increased use of pesticides, thus increasing the costs of production. The nuts harvested have compromised quality and thus difficult to market and fetch poor prices, decreasing incomes.

Decreased length of the production season does not allow all the production practices to be carried out. Seedling establishment is affected because the transplanting period is shortened; this leads to loss of seedlings in the seedbeds. Moreover, the farmer may not apply fertiliser and instead may use manure. This reduces sales by the agro-dealers, although it will reduce the costs of production at the farm.

Inadequate supply of seedlings from formal sources occasioned by reduced length of season force farmer to acquire seedlings from peers. As such, the farmers should be given adequate extension information on the right varieties and the required agronomic practices. For instance, the dwarf early-maturing variety could be recommended as the most appropriate variety since it gives high yields. The farmers should be trained on tree establishment, pest control, intercropping, and tending trees. Where production is low and of poor quality, nuts are sold directly to brokers and used for household consumption. To improve on the marketing, the farmers should be trained on harvesting, grading, and value addition so that they get better prices. They should learn how to separate the Fair Average Quality (FAQ) from the under grade (UG) nuts for better pricing. They should also be taught to process cashew apple, which fetches better prices.

Chicken (local)

Increase in temperatures and drought spells are the two main climatic hazards that pose the greatest risks to the indigenous chicken. The threat of drought affects the whole county. Increased temperatures mostly affect some parts of Witu, Mkunumbi, Hongwe, Bahari, Hindi, Manda Island, Kiduruni, and Kiunga. High temperatures have a moderate impact on procurement of feed and breeding stock, and a minor impact on housing material. Farmers incur high costs on material to ventilate chicken housing. The shelf life of the feed is affected by high temperatures; delicate vitamins and amino acids in the feeds are destroyed when temperatures rise beyond certain levels. During times of high temperatures, farmers reduce the number of birds in the housing to allow more space per chicken. Chicken take increased amounts of water and eat less. This leads to reduced growth rates. Incidences of respiratory diseases increase, so farmers spend more on drugs and vaccines. High temperatures reduce the shelf life of vaccines. All these production-related challenges were considered to affect farmers moderately. At the post-harvest stage, high temperatures result in high mortality at collection centres and during transportation. The shelf life of slaughtered birds decreases unless cold storage facilities are used. The impact of high temperatures on marketing are rated as moderate. However, the price of meat increases due to increased handling costs. Demand for meat therefore decreases, thus reducing sales.

Drought spells result in reduced availability of feeds for the chicken. The variety and quality (due to for instance aflatoxin contamination) of feed in the market decreases. Difficulties in sourcing for chicks lead to reduced breeding stocks. Costs increase marginally due to expenditure on building materials for housing. High temperatures effect on-farm production processes. Feed becomes scarce so the birds consume less and grow slowly or lose weight. The chicken require more attention in terms of care; watering and feeding. The number of birds slaughtered decreases so market prices increase. Most farmers make their own rations at home. In this connection, farmers should be trained on how to make own chicken rations using available materials, with emphasis on protein content. However, most homemade rations do not have adequate protein levels. The Department of Livestock is involved in capacity building for the farmers on good husbandry practices and feeding. Farmers do not pay much attention to treatment and vaccination of their chicken. They usually depend on indigenous technologies for treating chicken. The farmers need support on techniques that increase productivity through breeding, and on disease control. Some of the key breeding interventions that should be promoted are synchronised hatching, artificial incubation, chick management, and discouraging inbreeding. For disease control, assistance is needed on vaccination and isolation, improved sanitation, and strategic worm control. Farmers use collective action in marketing their chicken to access good markets. Poultry vending cages have been constructed in markets to reduce mortalities during marketing. ASDSP is funding the indigenous chicken value chain.

Fish

Increases in temperatures and reduced rainfall are the most critical climatic change hazards that threaten the fish value chain. Shores and channels are more likely to be affected when temperatures increase while deep-sea fishing is more susceptible to decreases in rainfall. Increased temperature has a moderate effect on the processing of fish but severe consequences on postharvest management and marketing. The input supply stage of the fish value chain involves purchase of fishing boats, boat engines, and fishing gear. High temperatures are associated with clear skies; fish in water are therefore able to see more clearly, so it becomes more difficult to catch those using hooks and fishing lines. The numbers of fish caught therefore decreases. Post harvest activities include on-board harvesting of the catch; this involves gutting, bleeding, and head cutting. The other activity is on-board and offshore chilling and transportation. All these processes require a cold chain since they rely on frozen ice. This stage is severely affected by increasing temperatures as they increase fish spoilage. The high temperatures also cause the ice to melt faster.

Since Lamu is remote from the markets in Mombasa and other counties, significant resources are invested in cold chains to get the fish to the market. This increases the unit price and hence the fish becomes less competitive compared to fish harvested in Mombasa and nearer fishing grounds. Therefore, in many instances the fishermen take low prices to sell the fish before it spoils.

Reduced rainfall does not affect acquisition of inputs in the fish value chain. It however has a major impact on prawns that inhabit brackish waters. This is where the fresh water mixes with the ocean saline waters. Reduced rainwaters reduce the river flows; hence, the amount of fresh water mixing with saline water and thus affecting the habitat for prawns. Reduced rainfall implies extended dry spells, associated with increased temperatures. This affects post-harvest processes as ice melts, making it difficult to keep the fish fresh between the fishing grounds and the landing grounds. More ice is used during transportation, thus increasing prices. The county government has established a revolving fund to support purchase of bigger boats, bigger engines, and modern fishing gear to allow deep-sea fishing. The county government, Beach management unit (BMU), Northern Rangeland Trust (NRT) and World Wide Fund for Nature (WWF) are building capacity of the fish value chain stakeholders on sustainable fishing techniques. In collaboration with BMUs, the county government BMUs is establishing a marketing infrastructure, including ice making plants and cold storage facilities. The farmers and fishermen in Lamu County are small scale and resource constrained, so the effects of the above hazards affect them more.

Adaptation to climate change and variability

On-farm adaptation practices

The Lamu County agricultural sector has experienced the impacts of climate change, the most prominent being extended droughts and delayed and depressed rains. This has led farmers and institutions to adopt adaptation strategies that counter the adverse effects of climate change. Majority of farmers in Lamu are smallholder and of low economic status. This makes them more vulnerable to the effects of climate change. The farmers are resorting to selection of crop varieties and types that are drought tolerant and early maturing. These crops include the maize varieties bred for the coastal climate, cotton, simsim, cashew nuts, and coconuts. They also keep livestock that can survive extended periods of drought with minimal feeding such as goats and indigenous chicken. Chicken have become very popular, especially the Kuchi chicken breed that fetches very attractive prices (over KES. 2000, approximately USD20 per bird). The county government Department of Agriculture, Livestock, and Fisheries is playing a key role in ensuring that farmers get seeds and information on these appropriate varieties. The county government distributes seeds for some of the aforementioned crops at the start of the season. Other key institutions supporting these initiatives are KALRO, NDMA and NGOs. These adaptation measures need to be improved by the county government by providing more resources for extension.

Use of irrigation in the county is limited to areas found around Mpeketoni and Tana Delta (Witu) are the main users. Irrigated farms grow mainly vegetables though cashew nut farmers apply some drip irrigation on their crops. The farmers also use water from shallow wells. The Department of Agriculture and Irrigation is supporting these efforts. For example, the department establishment the Jubilee Youth Group Irrigation Project in Mpeketoni. The biggest challenge hindering up-scaling of these irrigation initiatives is that most parts of the county have saline underground water that is not suitable for irrigation. Important water bodies like Lake Kenyatta that would have provided water for irrigation have dried up. Lamu County is generally flat, with the highest point being only 50 m a.s.l. This makes it difficult to use gravity irrigation. Dry spells

result in scarcity of fodder for livestock; some farmers resort to harvesting of grass in the forest. This however favours only those farmers who have vehicles or can afford to hire them. Pastoralists migrate with their cows to areas near Boni Forest where there is pasture. They also keep maize stalks and other crop residues to feed their animals during times of scarcity.

Climate change has resulted in destruction of fish breeding areas near the shores. Fishermen have to sail deeper in the sea to be able to capture greater amounts of fish. To counter this challenge, the fishermen are now resorting to deep-sea fishing, which requires bigger boats with engines that are more powerful. The fishermen are limited by lack of modern technologies like use of Global Positioning Systems (GPS) to map fishing grounds in the deep sea, use of fish finders and on-board processing abilities. To regenerate inshore fishing, the county government and Alkher Foundation are trying to establish cage fish farming in Matondoni. Investments should be made in developing cold storage facilities to help reduce post harvest losses. Additionally, efforts should be directed towards value addition by development of cottage industries and promotion of direct fish marketing to reduce length of the value chain.

There is over reliance on crop, livestock, and fish farming. To diversify farming, initiatives are under way to introduce apiculture as an alternative engagement that is less susceptible to drought and requires less capital and other resources to start. High temperatures pose great challenges on the quality of products in the value chains like poultry and fish. These value chains require investments in cold chain infrastructure. Small-scale farmers and fishermen experience high losses and sell their produce at low prices because they cannot store it for long periods. Supply of ice in Lamu County is limited as most of it is sourced from Mombasa; only limited amounts are made available, which makes it expensive. There are plans to bring investors in ice production to Lamu County. These value chains also suffer because there is very little collective action amongst the actors. Thus, there is need to establish cooperatives or organisations that the farmers and fishermen can use as avenues to procure inputs, invest in infrastructure, and source for lucrative markets.

The priority value chains in Lamu (Cotton, cashew nut, indigenous chicken and fish) could be improved by using appropriate technologies and good management practices. To improve productivity, the farmers should be trained and assisted to adopt varieties that are tolerant to drought, give high yields and are appropriate for the market. The dwarf cashew nut tree should be promoted because it is early maturing and high yielding. The Kuchi chicken should be promoted because of the high value of the chickens and their eggs. The farmers should be encouraged to practice good animal husbandry and proper agronomic practices for crops. Good agronomic practices in cashew nut production should be applied during land preparation, tree establishment, and weeding. For cotton, it would entail proper timing of planting, manure application, and intercropping. The farmers also need to understand pest and disease management strategies that are effective and environmentally friendly. Crop rotation, using clean seeds, use of natural predators for the pests, selection of varieties that are pest resistant, and use of chemicals are some of the key integrated pest management practices that can be deployed.

For chicken, the farmers need to be enlightened on good husbandry practices and balanced feeding to ensure the chicken are well nourished to increase productivity. In addition, they need to understand breeding strategies that will go hand-in-hand with good feeding. Key breeding practices that can increase productivity are synchronised hatching, artificial incubation, good chick management, and avoidance of in breeding.

Off-farm adaptation practices

Besides the on-farm interventions, other initiatives are being undertaken to manage the effects of climate change. The NDMA in Lamu conducts monthly field monitoring to gather drought early warning data. The monitoring gathers information on both biophysical (rainfall, VCI- data is provided by Boko University) and socio-economic indicators (livestock body condition, milk production & consumption, pasture & browse condition, grazing distances, distances to water sources, prices of cattle and goats, maize and beans, migration, coping strategies by the HHs, nutrition status of children <5yrs, income sources, food consumption score and any emerging issues. This information helps to design strategies to tackle foreseen climate change challenges. The NDMA also collaborates with the different relevant departments of the county government to disseminate information and help in implementing the designed plans. It also works with the communities in the affected areas to develop the community-managed disaster risk reduction (CMDRR) plans. These are long-term initiatives that allow the communities to come up with projects or endeavors that will cushion them against effects of climate change in the long-term and help mainstream them in local planning. As a member of the CSG, KMD works in collaboration with NDMA in giving weather outlook KMD and ASDSP also work to gather and disseminate information through the

PSP programme. The participatory scenario planning (PSP) is an instrumental approach but it has not yet worked in Lamu County.

Due to scarcity of water during periods of extended droughts, much effort is made to harvest water in the county. This is done through construction of water pans (Jabias). The areas that use this form of water harvesting are mainly Koreni, Kiunga, Mkunumbi, Dide-Waride, and Chalaluma. This is a very useful initiative because many parts of the county apart from Lamu Island have saline underground water, which is not appropriate for farming, livestock and household use. However, with extended droughts, the waters collected in the water pans are exhausted. Other ways to manage effects of climate change include diversification of income-generating activities. Household members take up casual work as off-farm labourers for example in quarries to earn income.

With insufficient rains, conservation farming should be adopted. However, farmers lack the necessary knowledge and tools to implement the practice. Currently extension services from the county government are limited. Farmer-to-farmer extension approaches are used, where farmers share information amongst themselves informally or through farmer groups. The county government Department of Agriculture and Livestock through extension services and NGOs are training farmers to adopt conservation farming techniques. For cotton production, they advise farmers on early land preparation and planting to take advantage of short rains. Northern Rangeland Trust (NRT) is working with livestock farmers to promote sustainable pastoral practices. Some of the initiatives they have are development of grazing plans, rehabilitation of areas with invasive plant species and building management structures for grazing areas. Despite all the efforts, information on weather and timing of agricultural activities is not accurate and timely, and does not reach the farmers in many cases. Additionally, financial and human resources limit the Department of Agriculture and Livestock; the staff cannot therefore effectively reach the farmers.

The Department of Fisheries, WWF, and the NRT are also involved in promoting sustainable fishing and rehabilitation and protection of fish breeding areas. They are involved in capacity building of fishermen and other stakeholders in the fish value chain. They strengthen the fisheries value chain management through supporting the Beach Management Units. They also discourage unsustainable fishing systems for instance beach seine fishing and encourage deep-sea fishing. NRT uses a market-oriented approach to encourage fishermen to venture into deep-sea fishing and use modern fishing technologies like hook and line.

For the priority value chains in this county to flourish, the county government should play a more active role in supporting them. The farmers need extra support in trainings and thus the county government should plan and invest in extension services. This is to equip the farmers with knowledge on the new technologies and management practices. Some of the key technologies packaged and disseminated are selection of appropriate breeds and crop varieties, management strategies for animal diseases, plant diseases and pests, conservation farming techniques, direct market opportunities, and investment in post-harvest handling infrastructure to reduce losses and enhance value addition.

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

Fish

	Provision of seeds and other inputs	On-Farm production	Harvesting storage and processing	Product marketing
Increasing temperatures	N/A	Reduced activity by fishermen. Reduced volume of the catch as fish move to deeper waters; slow sexual activity among the fish; low cloud cover aids fish visibility and reduces catch	Increased spoilage of fish. More ice required to maintain cold chain. Reduction of fish value and quality. High post-harvest losses	Lower prices. Less supply to outlets
Magnitude of impact		Moderate	Severe	Major
Farmers' current strategies to cope with the risks	N/A	Early morning fishing. Use of smaller net mesh sizes (catch smaller fish). Fishing in breeding zones. Moving further and further from the coast/shore to find fish	Sell quickly. Lower prices. Home consumption. Procurement of more ice. Drying of fish (using fire and sun) for preservation	Drying of fish and transporting them leads to loss of value; awareness creation and promotion of fish eating culture; procurement of cold chain; selling at the local market; sell to traders from other region
Other potential options to increase farmers' adaptive capacity	N/A	Promotion of motorized boats with cool boxes/ice packs for offshore fishing. Enforcement of standardized fishing net size. Train fishers on modern fishing and fish handling techniques. Awareness creation on effects of climate change on fisheries and suggested adaptation measures	Development of cold storage facilities for fish. Purchase of ice making plants. Construction of modern fish processing plants. Train fishers on value addition and invest in fish processing plants	Establishment of fish marketing centres. Improvement of market information systems. Exploration of both local and international (export) markets
Reduction in rainfall	Low acquisition of fishing gear hence supplier sales fall. Resources re-directed to emergency and recovery. Fish microcredit reduced	Reduction in brackish water required for prawn production. Reduced catch since fish migrate to deep water. Fishing in breeding sites leads to overfishing; Increase in illegal fishing activities. More time spent looking for fishing sites	Fewer fish available for processing and sales	Fewer fish available for sales. Lower supply to stores and marketing centres. Demand greater than supply
Magnitude of impact	Moderate	Major	Minor	Minor
Farmers' current strategies to cope with the risks	Informal borrowing of funds to procure fishing equipment (revolving fund mechanisms)	Fishing at night or during cool hours of the day. Fishing in breeding zones (unknowingly). Use of nonstandard nets (small mesh size). Use of GPS to identify good fishing zones	Home consumption of small fish. Basic preservation using water and ice buckets. Drying of fish (using fire and sun) for preservation	Informal marketing of fish. Minimal transport and sales to big markets
Other potential options to increase farmers' adaptive capacity	Ensure formal finance from microfinance institutes is available for fishing inputs	Use of motorized boats, with cold storage facilities and modern gear. Breeding site protection. Awareness creation on effects of climate change on fisheries and suggested adaptation measures. Promotion of modern cage culture for prawns	Construction of modern fish processing plants. Train fishers on value addition and invest in fish processing plants	Development of local fish marketing centres. Revamping/ capacity building of fish cooperatives. Exploration of both local and international (export) markets

Cotton

	Provision of inputs	On-Farm production	Harvesting storage and processing	Product marketing
Changes in seasons (onset and duration)	Reduced sale of agrochemicals. Incidences of stockists selling expired chemicals to farmers	Reduced cotton boll size and reduced lint yield. Delayed land preparation	Reduced quantity and quality of harvest. Reduced bulking and underutilisation of storage infrastructure. Less volume available for processing (both for informal and formal processers).	Unfulfilled contracts. Less volume for sales. Shortage of raw cotton for processors
Magnitude of impact	Minor	Moderate	Moderate	Moderate
Farmers' current strategies to cope with the risks	Use of expired chemicals. Sourcing of seeds and inputs by word of mouth	Reduce farm labour requirements. Intercropping with other crops	Reduce harvest labour requirements. Use of storage facilities for other purposes or crops	Import of raw cotton from neighbouring counties. Use of small vehicles for transport of raw cotton. Sales of raw cotton to neighbouring counties for further processing
Other potential options to increase farmers' adaptive capacity	Train farmers on local seed production and storage. Capacity build farmers/stockists on safe usage and stocking of chemicals. Development of early maturing, drought and disease resistant cotton varieties	Promote on-farm diversification. Promote irrigated cotton production	Creation of local certified warehouse receipt systems. Establishment of large cotton industries. Development of industrial park for cotton processing	Linkage of farmers/ cooperatives with intermediate/ domestic markets. Contract cotton growing
Drought / Moisture stress	Limited seed availability	Increased pests and diseases	Conditions for cotton harvest improve, however boll size and lint quality may be less due to water stress during the growing season. Storage and processing is also largely unaffected	High demand and high prices. Ease of sales to markets. Shortage of raw cotton for local processors
Magnitude of impact	Moderate	Moderate	Minor	Minor
Farmers' current strategies to cope with the risks	Sourcing of seeds and inputs by word of mouth. Reduce purchase and use of inputs and agrochemicals	Increased application of pesticides. Crop rotation to reduce pest and disease incidence	N/A	Sales of raw cotton to processors outside of the county
Other potential options to increase farmers' adaptive capacity	Support (microfinance and knowledge) agro-dealers to stock a variety of seeds and inputs. Seed cotton production contracts	Water harvesting and small-scale irrigation. Improved agro climatic advisory services. Train farmers on integrated pest and disease management	Creation of local certified warehouse receipt systems. Establishment of local cotton processing industries. Development of industrial park for cotton processing	Establish contract growing and marketing agreements. Improve feeder road infrastructure for transportation of raw cotton

Poultry

	Provision of seeds and other inputs 	On-farm production 	Harvesting storage and processing 	Product marketing 
Increasing temperatures	Poor health of chicks and increased mortality. Reduced feed availability and shelf life	Reduced feed consumption resulting in slower growth and delayed maturity. Increased costs for construction of temperature regulating enclosures with mesh and makuti. Increased water requirements Increased management requirements and incidence of respiratory disease	High costs associated with cold storage requirements. Increase in perishability of meat and eggs. Low quality and smaller chickens and eggs harvested. Increased mortality at collection centres	Increased transportation costs (fewer birds can be transported at once). Increased prices due to increased management costs
Magnitude of impact	Moderate	Moderate	Moderate	Moderate
Farmers' current strategies to cope with the risks	Farmer-to-farmer sharing of information on health management. Use of local ingredients to supplement feed	Reduced stocking density to minimise heat stress from overcrowding. Improved (ventilated chicken housing). Watering of chicken enclosure to reduce temperatures. Use of indigenous knowledge for health management of chickens	Slaughter at household level. Formation of small poultry groups	Local household consumption. Transport using small cages with few birds. Sales at local poultry sales yards
Other potential options to increase farmers' adaptive capacity	Training on production and conservation of homemade feeds. Promote feed milling using locally available materials	Train farmers on construction of improved (ventilated and temperature regulating) enclosures	Establishment of processing facilities for value addition. Capacity building of poultry groups on packaging and value addition. Establish cold storage facilities at trade centres	Capacity building of poultry groups on marketing. Procurement of specialised poultry transport vehicles. Establish contract chicken farming. Increase number of shaded poultry sales yards
Droughts / Moisture stress	High mortality rate of chicks. Feed shortages and increase in prices of inputs. Quality of available feed is reduced	Increased need and costs for veterinary care. Increased costs related to provision of feed, water and housing. Reduced feed intake by chickens. Reduced productivity and profitability	Reduced quantity and quality of eggs harvested. Reduced number of chickens slaughtered due to low production. Increased cold storage requirements and costs. Increased collection and transportation costs	Reduced household income from chicken and egg sales. Lower prices for farmers, higher prices for consumers (increased profits for middlemen and traders).
Magnitude of impact	Moderate	Major	Major	Moderate
Farmers' current strategies to cope with the risks	Farmer-to-farmer sharing of information on drought and health management. Use of local ingredients to supplement feed	Reduction of the flock. On-farm rationing of feed. Diversification to other enterprises	Formation of small poultry groups. Slaughter at household level	Local household consumption. Transport using small cages with few birds. Sales at local poultry sales yards
Other potential options to increase farmers' adaptive capacity	Training on production and conservation of homemade feeds. Promote feed milling using locally available materials (including support to procure equipment)	Training farmers on affordable and modern (ventilated) enclosure construction. Capacity building on improved health management	Establishment of processing facilities for value addition. Capacity building of poultry groups on packaging and value addition. Establish cold storage facilities at trade centres	Use of specialised poultry transport vehicles. Contract chicken farming. Increase number of poultry sales yards. Establish chicken sales/ marketing days

Cashew nuts

	Provision of seeds and other inputs 	On-farm production 	Harvesting storage and processing 	Product marketing 
Changes in seasons (onset and duration)	Unavailability of seedlings that are ready for planting. Disruption in planting activities	Delays in land preparation. Delayed planting. Increased weeds, pests and diseases. Higher labour costs over a longer period	Low quality and quantity of produce. Low household incomes. Underutilized processing capacities. Loss of produce in the field	Low volumes for marketing. Missing market timing. Difficulty in meeting quantity, quality and timing requirements of buyers
Magnitude of impact	Moderate	Major	Major	Major
Farmers' current strategies to cope with the risks	Sourcing seed from neighbouring farmers. Procurement of seedlings from research centres (KALRO Mtapwa). Planting without fertilizer application. Farmer-to-farmer information sharing on seasons and climate	Diversification to other activities. Early land preparation using family labour. Low cost drip irrigation used by some	Limited storage. Limited value addition. Household consumption. Roasting for local sales and consumption	Farm gate sales. Sales at local markets. Sales to middlemen. Household consumption
Other potential options to increase farmers' adaptive capacity	Establishment of local commercial seedling nurseries. Training on grafting and seedling propagation. Bulk/ group procurement and storage of seedlings, fertilizer and other inputs. Establishment of digital climate information sharing facilities	Promotion of conservation agriculture. Support for mechanised tilling services. Enhance water harvesting and scale irrigation development. Capacity building on use of organic manure and compost. Training on orchard management	Bulking of farm produce through cooperatives. Capacity building on value addition, packaging and marketing. Establishment of bulk storage and processing facilities	Promote contract farming. Formation / capacity building of producer and marketing groups. Improve market information availability
Droughts / Moisture stress	Loss of seedlings in nurseries and in the field. Reduced purchase and application of fertilizer and manure	Extra labour (and costs) for land preparation. Wilting of plants. Drastically reduced productivity	Reduced volumes and quality of harvest. Low prices. Default on loans. Underutilized storage and processing capacities. Loss of produce in the field	Low supply to market. Reduced income for farmers and traders
Magnitude of impact	Major	Major	Major	Major
Farmers' current strategies to cope with the risks	Neglect of old plants. Farmer-to-farmer information sharing on seedling management and availability of inputs	Reduced spraying and fertiliser application. Low cost drip irrigation used by some. Planting without fertilizer application	Limited storage. Limited value addition. Household consumption. Roasting for local sales and consumption	Farm gate sales. Sales at local markets. Sales to middlemen. Household consumption. Reduction of prices to enhance sales
Other potential options to increase farmers' adaptive capacity	Enhanced agrometeorological information using ICT. Introducing high yielding and drought resistant varieties	Water harvesting and small-scale irrigation development. Establishment and training on use of compost. Scaling up of conservation agriculture. Rehabilitation of old orchards. Training on use of IPM	Bulking of farm produce through cooperatives. Capacity building on value addition, packaging and marketing. Establishment of bulk storage and processing facilities	Promote contract farming. Formation / capacity building of producer and marketing groups. Certification system with relevant body to enhance sales

Policies and Programmes

The county implements policies and programmes aimed at reducing the impacts of weather variability and climate change. NDMA plays a pivotal role in climate change adaptation programmes. It provides early warning information that is shared with all the relevant county departments and stakeholders. They also coordinate the articulation of the contingency plans that address drought emergencies and the Community Managed Disaster Risks Reduction plans (CMDRR). The county government plays an important role in implementing some of the policies and programmes through its departments: Agriculture and Irrigation, Livestock, Fisheries, and Cooperative Development, and Natural Resources Management. These efforts are also in line with the national policies that promote good nutrition, availability of food to the people, and protection of vulnerable populations. Despite the county government being part of the steering group and working in collaboration with NDMA, it needs to plan and budget for interventions that will guarantee food production as well as contingencies during drought disasters.

The Department of Agriculture and Irrigation has adopted the National Irrigation Policy of 2015 that promotes expansion of irrigation, water harvesting, and creating the framework to guide development of irrigation projects. The department has established irrigation projects in Mpeketoni, Chalaluma delta, MOA, Kitumbuni (Witu), Uziwa (MUUM), Maleli, and Nyati. The projects are geared towards increasing production under irrigation. Unfortunately, irrigation is constrained by the saline ground water, drying up of Lake Kenyatta, and generally flat topography that impedes the gravity irrigation system

A number of projects support the livestock sector in the county; this is in line with the National Livestock Policy of 2008. The policy intends to develop the livestock sector in the areas of breeding, nutrition and feeding, disease control, value addition and marketing, and research and extension. The county government provides vaccinations against diseases associated with movement of livestock especially in the dry seasons. The NRT through its range management project is working with pastoralists to ensure sustainable use of the rangelands. The county is also a beneficiary of the five-year Regional Pastoralists Resilience project initiated in 2014 and funded by the World Bank. The project works to improve exploitation of natural resources, access to markets, livelihood support, and risk management. It is implemented in collaboration with the Department of Livestock Development.

The Department of Fisheries Development, NRT, and WWF have initiatives that promote sustainable extraction of the ocean resources i.e. fish and Mangrove. They focus on capacity building of stakeholders on the importance of sustainable fishing and mangrove logging. They also contribute towards strengthening the capacity of the BMUs, which are self-regulating institutions of the fish value chain. WWF and NRT also work with the KWS to ensure conservation of marine parks and fish breeding grounds. NRT is responsible for conservations of following ecosystems; Awer, registered in 2013 mainly focuses on wildlife, Pate that is focuses on a marine ecosystem registered in 2012 and Hanshak-Nyongoro registered in 2012 and concerned with promoting peace and resource conservation.

NRT also helps in market linkages for fish captured in the deep sea; this encourages fishermen to venture into the deep sea. The Department of Lands and Natural Resources has a project for tree planting in Kiunga, Lamu, and Hongwe. The project is intended to increase the tree cover in the county.

Governance, institutional resources, and capacity

The NDMA is a government agency whose mandate is to design strategies that will prevent drought emergencies and mitigate the effects of climate change. It is an important and instrumental institution in coordinating and implementing initiatives related to reducing the impacts of weather variability and climate change. It works in collaboration with all the government agencies, the national government, and the county government. Their initiatives are for emergency and for creating long-term resilience. NDMA involves the county government departments and other agencies such as NEMA, KRCS, WV KFS, and KWS in planning through the county steering group that is co-chaired by the County Commissioner and the Governor. They conduct bi annual food security assessments, rapid assessments, generate and share early drought warning information. They have contingency plans as well as community-managed disaster risk reduction plans (CMDRR). The contingency funds are used for drought emergencies while the CMDRR is to create long-term strategies that are embedded in local plans. The drought contingency interventions funded through the National Drought Contingency Fund with support from the EU financed through Kenya Rural Development Programme (KRDP) During the 2016/2017 drought, NDMA provided food items for fees, concentrates for livestock, slaughter destocking, and commercial off-takes, provision of aqua tabs, provision of fuel subsidy to desalinating plants, livestock vaccination and tsetse control, water trucking and provision of plastic water tanks to communities and institutions' peace meetings

The county government through the Departments of Agriculture and Irrigation, Livestock, Fisheries, and Cooperatives, and Natural Resources Management have programmes that intend to help communities cope with the effects of climate change. These departments do not have plans that are focused on climate change issues but some of the activities are related to climate change. The departments' plans are based on the five-year CIDP of Lamu but each prepares their plans independently. The departments are faced with challenges of inadequate financial and human resources that limit their efforts. The county government has also not mainstreamed climate change in its planning and budgeting. Nevertheless, the departments have knowledgeable and competent staff in technical and policy-related issues. The staff are also used by other NGOs such as WWF, NRT, and NDMA to help in implementation of projects.

World Wide Fund for Nature (WWF) is an international NGO that focuses on environmental conservation. It has a programme called Coastal Kenya Program that covers the Kenya coastal counties, Lamu being one of them. They focus on marine and terrestrial conservation. In marine conservation, they concentrate on protection of species and conservation fishing. On terrestrial conservation, they are working on conserving the Boni-dodori Forest. They also support livelihoods and capacity building initiatives. Their plans and programmes are based on broad global objectives and cascaded down to the country and regional goals. They work with the County Department of Fisheries, Lands, and Natural Resources and KWS in planning and implementing their projects.

The Northern Rangeland Trust (NRT) is a community-led non-governmental organisation working in northern Kenya and the coast; its membership includes local leaders, politicians, and conservation interests. Their main donors are The United States Agency for International Development (USAID), The Nature Conservancy, Danish International Development Agency (DANIDA), and Agence Française de Development (AFD). The NRT works with communities to implement sustainable natural resource management plans, monitor fishing, and build their capacity for effective governance. Their interventions are in the areas of marine and terrestrial ecosystems. They promote marine conservation in Pate and Kiunga, Boni Forest in Awe, and Livestock Rangelands in Hanshook-Nyongoro. They engage in both project implementation and research. They support the BMUs and other community-based organisations that manage natural resources. NRT works very closely with the county government other government agencies like KWS and KFS. Lamu County is a key contact point by government, NGOs, and other organisations that want to work with stakeholders in the fishing industry. They are an avenue to promote new technologies, laws, policies and regulations, trainings and capacity building. Their source of funding is registration and renewal fees, some monies from county government, and charges of boats and fish caught. Organisations such as NRT and WWF support some of the BMUs initiatives and activities. Insecurity is a major problem that affects all the institutions and programmes working in Lamu.

Synthesis and Outlook

Climate change affects the agricultural sector in Lamu County considerably. The county is threatened by uncertainty in seasons (onset and duration), moisture stress, increase in temperatures, reduction in rainfall, and drought. All these have far-reaching effects on crop production, livestock rearing, and fishing, key activities of the agricultural sector of Lamu. The national government, county government, government agencies, and NGOs have initiatives to manage the consequences that result from these harsh climatic conditions. The county government is investing in irrigation projects to increase production. They are also offering extension services to farmers and disseminating new technologies. In addition, there is the government seed distribution programme to ensure farmers have appropriate seeds at planting time. They also advise the farmers on the appropriate crops to grow given the prevailing conditions. Part of the extension has provided farmers with knowledge on good agricultural practices like early land preparation and planting; the knowledge goes a long way in managing water from depressed rains. The communities are also being involved in water harvesting using water pans (Jabias).

Livestock farmers use crop residues to feed their livestock during periods of scarce fodder; those with means harvest grass in the forest to feed their animals. Pastoralists move to areas near the forests to graze their livestock. The Livestock Department and NDMA have been encouraging farmers to keep small livestock like goats and chicken that can withstand scarcity of feed. For the fishing value chain, the fishermen are being given incentives to venture into deep-sea fishing to reduce pressure on on-shore fishing. The county government revolving fund helps the fishermen to procure bigger boats that can venture far into the ocean. There is a number of initiatives by the county government departments; NGOs,

and other government agencies to train crop and livestock farmers as well as fishermen on sustainable resource use. The NDMA plays an important role in coordinating climate change initiatives, providing early warning information over and above their drought contingency interventions and building community resilience and preparedness. The communities are also taking up alternative activities like apiculture and off-farm activities like casual labour.

The efforts to develop climate change risk strategies is a combined and complementary initiative of the NGOs, the government, and government agencies. NDMA plays an important and instrumental role in coordinating as well as implementing climate change adaptation and mitigation measures. In Lamu, WWF and NRT are involved in the pursuit of sustainable and conservative use and management of natural resources. The county government plays a pivotal role of providing technical expertise and knowledge that is harnessed by the different stakeholders to implement their development initiatives.

Despite these efforts, it is evident that climate change has not been mainstreamed in the county government's planning and budgeting. Moreover, the different county government departments do not undertake coordinated planning for their activities. This results in duplication of roles and loss of synergy. Besides WWF and NRT, the rest of the players are not involved in research. In spite of the important roles played by the NGOs in managing climate change, their mandate is limited and many times guided by their main objectives; accordingly, their roles might not be flexible.

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