

Climate Risk Profile Makueni County

Highlights

- The agricultural sector is an integral component of the economy of Makueni County. It employs approximately 78% of the population and contributes a similar percentage to household incomes. The major agricultural value chain commodities with respect to income generation, food security, and production include local poultry, green grams, mango, and dairy cows.
- Climate change and variability remain a big challenge to the agricultural sector in Makueni. Maize yields have been declining since 1994. In 2013, there was a 70 - 90% crop failure in the County (agro-ecozone [AEZ] LM5) with major crops like maize, cowpea and green gram registering 42%, 74%, and 79% decreases in productivity. This left about 60,000 people dependent on food assistance.
- Drought, heat stress, increased precipitation, moisture stress, and increased temperatures are the most problematic climatic hazards in the County. Analysis of past climatic events and future climatic projections for the County indicate that these hazards are likely to increase in frequency. Past climatic events have shown that drought is more likely to occur in AEZ LH4, LH5 and LM6 which include Makindu, Kalawa, and Mtitu Andei. Increased precipitation is likely to occur in the wetter areas such as Kilungu and Mbooni, which fall under AEZ LH2.
- In response to the current and projected hazards, approximately 92% of the farmers have adopted at least one adaptation strategy. On-farm adaptation strategies for livestock producers include fodder and feeds conservation, use of simple treatment methods such as deworming and hoof trimming, and value-adding activities such as cooling and boiling for milk. Adaptation strategies used by crop farmers include use of early-maturing and drought-tolerant crops, conservation agriculture, seed recycling, home nurseries for seedling production, irrigation, and use of manure. Water harvesting and agroforestry are strategies adopted by both livestock and crop farmers.
- Resource constraints and poor market linkages are major impediments to uptake of adoption of options by farmers, despite current support provided by various government and non-government institutions.
- Off-farm services accessible by farmers to improve their adaptive capacity include extension and training, fodder conservation, credit, storage, value addition, early warning information, and production inputs. Actors offering such services like the Ministry of Agriculture, the Anglican Development Service, Financial institutions such as the Universal Traders Limited (UTL), the Kenyan Meteorological Department (KMD) and community- and faith-based organizations among others lack the necessary resources to cover the entire County. This results in unequal coverage of various parts of the County.
- Makueni is the only County in the country with a climate change policy, the County Climate Change Fund (CCCF). The policy requires that 1% of the County budgetary allocation be allocated to climate change interventions. Unfortunately, gaps in some sectors hinder implementation of intended interventions. For instance, only 20% of land owners have title deeds
- In this sense, successful implementation of climate adaptation strategies requires strengthening of institutional and financial capacity of key actors so that they are able to deliver basic resources and agricultural incentives to the population, and so keep farmers engaged in sustainable agricultural activities. Farmers need the tools and information to understand and urgently adopt measures to mitigate the risks associated with climate change.

List of acronyms

ABM	Anglican Board of Mission
ADS	
AEZ	Agroecological Zone
AGRA	Alliance for a Green Revolution in Africa
ASAL	Arid and Semi-Arid Lands
ASDSP	Agricultural Sector Development Support Program
BISEP	Business Initiative for Survival and Eradication of Poverty
CCCF	County Climate Change Fund
CCCFMB	County Climate Change Fund Management Board
CEC	County Environment Committee
CIDP	County Integrated Development Plan
CSA	County Sand Authority
DfID	Department for International Development
EMCA	Environmental Management Coordination Act
EWIS	Early-Warning Information System
FAO	Food and Agriculture Organization of the United Nations
FIPA	Farm Input Promotions Africa
GoK	Government of Kenya
IPM	Integrated Pest Management
KALRO	Kenya Agricultural and Livestock Research Organization
KAPAP	Kenya Agricultural Productivity and Agribusiness Program
KAPP	Kenya Agricultural Productivity Program
KMD	Kenya Meteorological Department
NDMA	National Drought-Management Authority
NEMA	National Environment Management Authority
PRISE	Pathways to Resilience in Semi-Arid Economies
SUAC	Sand Conservation and Utilization Act
USAID	United States Agency for International Development
UTL	Universal Traders Limited
WCMA	Wildlife Conservation and Management Act
WB	World Bank
WFP	World Food Program



Foreword

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

Presented here is the County Climate Risk Profile for Makueni County, where climate variability has been accompanied by a significant increase in attendant risks, as repeatedly reported in national news coverage. In 2015, Makueni experienced particularly heavy rainfall that resulted in floods and mudslides that destroyed hundreds of homes and left much of the agricultural County dependent on food aid¹. Cycles of drought and extreme heat likewise threaten natural habitats and farmers livelihoods: in 2016, Makueni was identified as a hot spot for human-wildlife conflict resulting from the scramble for scarce water and pasture resources². The County government and national research organizations have taken steps to help farmers prepare for, and respond to, the threat of flood and drought, for example, through the dissemination of inputs like certified seeds and information on topics like the construction of Zai pits³. The County has also attempted to better distribute findings from weather

forecasts to help farmers operationalize contingency plans in the face of La Niña and El Niño conditions. The disastrous nature of severe drought makes the identification of impending climate risks an urgent matter. Likewise, considering how practices that help citizens become more resilient in the face of imminent threats to their health, safety, and livelihoods becomes an exercise with the potential to affect hundreds of thousands of lives.

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

1 As reported by online newspapers Star and Monitor (Star, 2015; Monitor, 2015)
2 As reported by the online newspaper Star (Star, 2016).
3 As reported by online newspaper Daily Nation (Daily Nation, 2015).

Agricultural context

Economic relevance of farming

The County of Makueni is located in the eastern part of Kenya. It borders Taita Taveta County to the South, Machakos County to the North, Kajiado County to the West and Kitui County to the East. It covers approximately 8,034.7 km², most of which is arid and semi-arid (GoK, 2014). The County is characterized by a low-lying terrain except for the hilly areas such as Kilungu Hills, Mbooni Hills and Chyulu Hills. The natural resources in the County include forests, mainly found in the hilly regions, the Chyulu National Park, and perennial rivers such as Athi, Thwake, Kiboko, and Kambu.

The County receives long rains in March and April, and short rains in November and December. The rains are not evenly distributed across the County. The hilly regions of Kilungu and Mbooni receive about 800-1200 mm of rainfall (above normal) whereas the lower areas such as Kibwezi receive below normal rainfall of about 300 mm. The temperatures range between 20.2 and 35.80 degrees centigrade, with the hilly areas being relatively colder compared to the low-lying regions (GoK, 2013).

Agriculture is the main income-earning activity. The sector employs about 78% of the population and contributes a comparable percentage to the household incomes (GoK, 2013). Agricultural activities practised in the County include crop farming (cash crops and food crops), livestock keeping (mainly dairy and beef cattle, goats, and poultry), bee keeping, and fish farming. In 2013, the County received about 2 billion and 10.3 million Kenya shillings (KES) respectively from the major crop and livestock enterprises⁴ (GoK, 2014). In the livestock sector, the highest contribution came from milk (89%) whereas in the crops sector, mango, maize and cowpea contributed 26%, 23% and 20% respectively⁵.

People and livelihoods

The population of Makueni was estimated at 884,527, with nearly equal numbers of male and female populations according to the 2009 National Census (KNBS, 2013). It was anticipated to be growing with

2.3%⁶ by 2017 (GoK, 2013). The urban population is estimated at 4%, mainly concentrated in the two major towns, Wote and Mtito Andei. The urban population is anticipated to increase rapidly owing to devolution, the current construction of the Standard Gauge Railway passing through Mtito Andei, and youth migration to urban centres in search of employment.

Makueni County has one of the highest poverty levels in the country (64%) compared to the national absolute poverty level (47%). The high poverty level is attributed to several factors, the main one being low agricultural productivity (mainly due to water scarcity, poor soils) and high unemployment rates. The County also has a rather low Human Development Index (HDI) of 0.48, mainly given the poor access to basic social services (GoK, 2013b). For instance, the distance to a source of water and health facility is about 8 and 6 km respectively. Only about 1% of the population uses electricity for cooking; approximately 6% use electricity for lighting. Around 85% use firewood (GoK, 2013).

Food poverty rates are also high in the County (57%)⁷, given low agricultural productivity brought about unfavourable climate. This has resulted in over-reliance on aid and household members skipping meals, which leads to malnutrition. Female-headed households being worse off compared to male- and youth- headed households due to lack of ownership of assets and production inputs such as land (GoK, 2013)⁸.

The major economic activities include livestock rearing, crop farming, agroforestry, sand harvesting, charcoal burning, and brick making. The major livestock types found in the County include cattle, pig, sheep, goat, poultry and donkey. The major crops produced include green gram, sorghum, maize, mango, cowpea, bean, pigeon pea and citrus. Sand is a major resource in the County, but since sand harvesting is illegal, its contribution to the County income has not been established.

4 1 USD is an equivalent of 90 Kenyan Shillings (KES).

5 The figures were obtained from aggregations as presented in the ASDSP (GoK, 2014).

6 The relatively low growth rate is attributable to the high awareness and use of birth control methods as one strategy of reducing pressure on the fragile land and food insecurity.

7 Food poverty refers to the population that does not have access to enough food to meet the daily dietary requirements.

8 Youth refers to persons between the ages of 18-35 years whereas female and male adults refer to persons above the age of 36.

Agricultural activities

The County is categorized into several agro-ecological zones (AEZs) (Karanja, 2006; Jaetzold et al., 2010):

LH 2, also known as the Wheat/Maize-Pyrethrum Zone, is at an altitude of 1400 - 1770 m and receives about 1000-1300 mm of average annual rainfall.

- UM 2, also known as the main Coffee Zone, is at an altitude of 1400 - 1770m and receives about 980-1200mm of average annual rainfall.
- UM 3, also known as the Marginal Coffee Zone, is at an altitude of 1400 - 1830m and receives about 950-1050 mm of average annual rainfall.
- UM 4, also known as the Sunflower Maize Zone, is at an altitude of 1520 - 1770 and receives about 800-950mm of average annual rainfall.
- UM 5, also known as the Livestock Sorghum Zone, is at an altitude of 1460 - 1710m and receives about 600-750 mm of average annual rainfall.
- LM 3, also known as the cotton zone, is at an altitude of 1160-1350m and receives about 800-900mm of average annual rainfall.
- LM 4, also known as the Margina Cotton Zone, is at an altitude of 1160-1280m and receives about 700-850 mm of average annual rainfall.
- LM5, also known as the Lower Midland Livestock-Millet Zone, is at an altitude of 790-1220m and receives about 650-750mm of average annual rainfall.

Generally, the AEZs are broadly understood as the upper zone (mainly Kilungu and Mbooni) popular for production of milk, maize, avocado, and vegetables; the middle zone (Wote area) suitable for production of maize, mango, oranges, and beans; and the lower zone (Kibwezi areas) that is suitable for production of pastures and beef cattle.

Land in Makueni is categorized into arable land, non-arable land, and forest land measuring 504,269, 176,271, and 15100 ha respectively. This translates to 63%, 23% and 2% of County land and 9%, 3.2% and 0.4% of country land respectively.

Only about 20% of land owners have title deeds (GoK, 2013). Secure land tenure has been associated with strengthening security of investments in land improvement so that farmers can undertake long-term soil conservation interventions (Evenson and Pingali, 2007). Farming is mainly for subsistence purposes under mixed production (Mwangangi et al., 2012); farm sizes range from 3.44 to 30.4 ha (GoK, 2013) for small- and large-scale farms respectively. Agriculture is rainfed as only 9% of the households practise irrigation (Mwangangi et al., 2012).

Utilization of agricultural inputs such as fertiliser, manure and herbicides is very low. For instance, Mwangangi et al. (2012) observed that more than 94% of the farmers never used fertiliser. The ASDSP survey of 2014 showed that farmers use more inputs during the long rains compared to the short rains. Utilization of improved seeds was highest in maize. Herbicides were mainly used in pigeon pea, basal fertiliser in common bean, and manure mainly in mango (GoK, 2014). The low utilization of inputs is attributed mainly to prohibitively high prices and scarcity of water, coupled with unfavourable cultural practices. It was reported that the farmers believe that fertilisers make the soils poorer, and that crops are more drought resistant in fields without fertilisers.

Agricultural value chain commodities

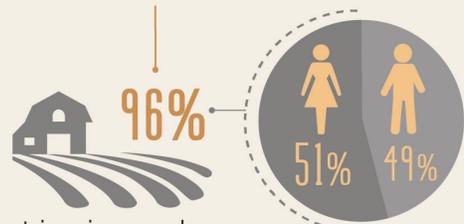
Despite the County being semi-arid, a rich diversity of crops is grown here. Some agricultural value chains have been promoted by different government organizations and programmes such as the Agricultural Sector Development Support Programme (ASDSP), the Kenya Agricultural and Livestock Research Organization (KALRO) and University of Nairobi survey, and the Kenya Agricultural Productivity Program (KAPP). For the development of this County Climate Risk Profile, four major value chain commodities (VCCs) were selected for in-depth analysis, based on their contribution to food security, productivity characteristics and importance to the economy. These agricultural VCCs have been selected from a list compiled from the above-mentioned programmes/documents as well as the Economic Review of Agriculture (GoK, 2015) using the following prioritization indicators: harvested area (hectares), production (90 kg bags for crops and litres for milk),

Livelihoods and agriculture in Makueni

Demographics

2.4% Of Kenya's population

922,185 inhabitants



96% Live in rural areas

Access to basic needs

64% of the population lives in absolute poverty

Potable water	18%
Electricity for cooking	0.2%
Electricity for lighting	6%
Education (youth literacy rate)	86%

Food security

57% of the population suffers from food poverty

ND of household income spent on food

ND People undernourished
 ND Children stunted
 ND 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)

Makueni

County's farming area

504,269 ha 63%

42% of the population employed in agriculture production

20% of farmers have title deeds ND% are women

Farming activities

Food crops



Cash crops



Livestock



ND Group ranches
 ND Company ranch

Of county's agricultural land

Farming inputs

Water uses



Fertiliser types (% of households)



Pesticide types (% of households)



variation in production (in the past five years, value of production (KES), dietary energy consumption (Kcal/capita/day), protein content (g of protein/ 100 g of product), iron content (mg of iron /100 g of product), zinc content (mg of zinc/100 g of product), and Vitamin A content (IU Vitamin A/100 g of product).

The selected agricultural value chain commodities for further analysis in the study are green gram, mango, local poultry, and dairy cow. Annex 1 summarizes the indicators used for the systems selection.

Green gram

Green gram is produced mainly in AEZs LM4, LM5 and LM6 mostly during the short rains – (November and December). The crop is grown for food and income and is preferred due to its tolerance to the harsh climatic conditions in Makeni. The common varieties in the County are Nylon 26 and uncle. Nylon 26 is preferred for its tolerance to diseases, high dry matter and yields and good taste. Uncle is popular due to its early maturation and bigger size. The variety also attracts a higher price relative to nylon 26, though it requires much more pesticide.

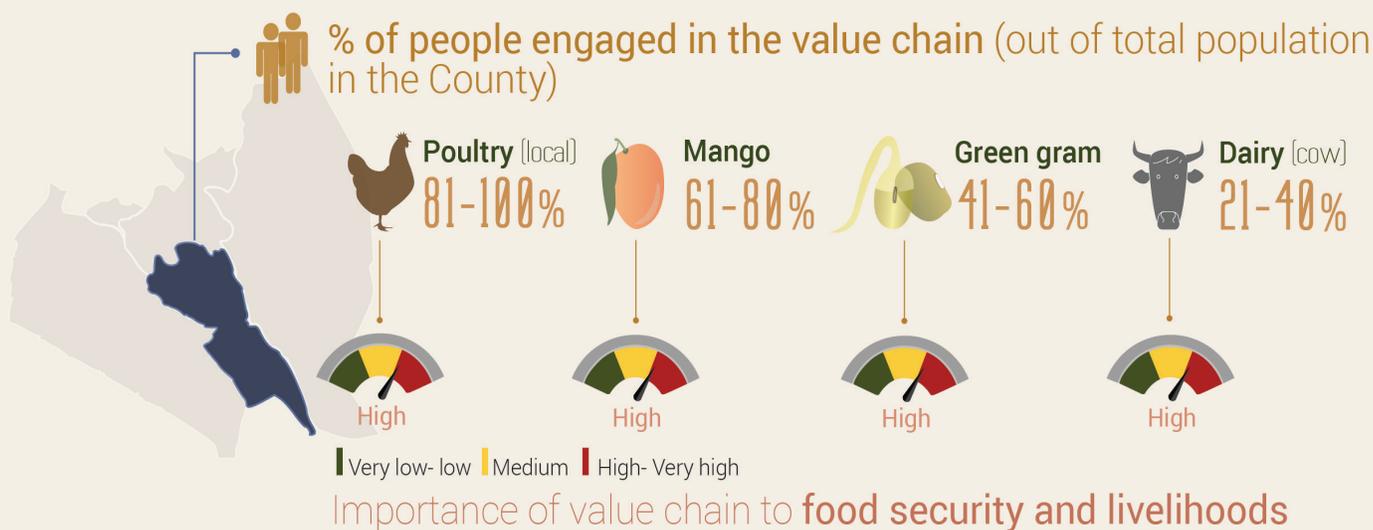
The green gram value chain engages about 41 - 60% of the population, women and men alike. There is no clear information on which duties are done by men

and women, though it was reported that sometimes men are the decision-makers in selling the green grams. Production is mainly at small- and medium-scale levels. The area under green gram ranges from 2 to 5 acres (within the farms).

Input suppliers are small-scale agrovets and a few companies such as Dryland Seed Companies. Various private organisations, NGOs, and government institutions such as KALRO supply farmers with inputs. The same organizations also link the farmers to markets.

Green gram yields 3 to 4 90 kg bags/ha, which represents half of the potential of 6 to 8 - 90 kg bags/ha. Productivity is highest (408 kg/acre) on farms belonging to youth-headed households during the first season (short rains) and lowest (91 kg/acre) on farms belonging to female-headed households. In the second season (long rains), it is highest on farms belonging to female-headed households (168 kg/acre) and lowest on farms belonging to youth-headed households (65 kg/acre) (Annex 2) (GoK, 2014). Low production in the second season is associated with minimal utilization of organic manure. Use of purchased inputs such as inorganic fertilisers and pesticides was found to be more common among male- than among youth- and female-headed households. High prices and unavailability of commercial inputs are the major reasons for the low utilisation of purchased inputs.

Agricultural value chain commodities in Makeni



Individuals and groups market the harvest. A large portion of green gram produced in Makueni is sold outside the County. Green gram is in high demand especially in the dry season. Farmers in the County hardly store the produce; storage facilities are scarce and value addition is limited to sorting/grading. Hermetic bags that prevent attacks by pesticides and contamination by aflatoxin are prohibitively expensive for the common farmer.

Mango

Mango is mostly produced in the middle zone (LM4 and LM5) mainly for commercial purposes. The most preferred variety is apple since it fetches a higher price compared to kent and ngoe. About 61 - 80% of the population are involved in the value chain. Production, input supply, and processing are at small-scale level. Although mango production engages all members of the household, production decisions are mainly made by men. Also, men and youth dominate transportation.

The current productivity for mango is 180-200 pieces/tree against the potential of 500 pieces/tree. Productivity is highest (5,259 kg/ha) among the male-headed households compared to youth- and female-headed households (247 and 3,670 kg/ha) (GoK, 2014). This difference in productivity may be attributed to the fact that the mango trees owned by the youth have been recently established and may not have attained the stage for peak production. Low productivity on farms belonging to female-headed households may be due to low utilization of inputs such as fertilisers and use of grafted mangoes. Better access to credit, research, input and output markets and land by the male- and female-headed households may be additional factors contributing to the high mango productivity among men and youth.

The major challenges in mango production include pests - mainly fruit fly, disease such as rust and anthracnose, scarcity of water which leads to high abortion rates, and small fruit sizes. These challenges, coupled with disorganized markets, force farmers to sell to middlemen at very low prices. The price is normally KES 2-3 a mango for the small sizes and KES 8-12 shillings for the big sizes mangoes, though the prices largely depend on the buyer. The prevalence of pests and diseases has increased since spraying is

impaired by scarcity of water. As a result, fruit fly has become more resistant to the available pesticides, thus becoming a menace in the County. The alternative of using fly traps is too costly for most of the farmers.

Value addition activities for the value chain include bulking, drying, and processing. It was reported that activities such as drying help in increasing the mango shelf-life but also fetching higher prices. This activity is mainly carried out by women in groups who use solar energy. Political intrigues were reported to impair large-scale value addition. For instance, it was mentioned that construction of the Kalamba Mango processing plant has been derailed, as some politicians lobby for exporters.

Local Poultry

Local poultry is an important value chain in terms of food security and income generation. The birds are kept for both meat and eggs. The total indigenous poultry population in the County in 2014 was at 891,891, whereas the meat and egg production was at 4,252,200 kg and 883,868 trays respectively⁹. Local chicken is a preferred value chain since the chicken can tolerate the harsh climate. Nevertheless, challenges faced by the farmers include feed and water scarcity, factors which contribute to low productivity.

Over 80% of the population is engaged in the value chain. Productivity of local chickens, which is determined in terms of survival rates, is 30%, barely half of the potential of 70%. Production, input supply and processing is at small scale, where farmers own about 35-100 birds per household. There are no processors in the value chain, and as such value addition is limited to de-feathering, differentiation of parts, packaging and boiling, and is mostly practised by men. The local market is the major outlet for the chickens and eggs. An egg can cost KES15-50 depending on whether it is for consumption or brooding. A chick costs KES 100-250, whereas a mature chicken can sell for KES 500-800. In 2013, youth- headed households registered the highest number of eggs sold (2,846) compared to both male- and female-headed households (735 and 64 respectively) (GoK, 2015). The low number of eggs sold by women may be due to utilization of the eggs for other purposes such as household consumption and brooding.

⁹ The production figures do not specify meat from broilers as well as eggs from layers, though the population of broiler and layers was relatively low (27,433 and 46151 respectively). A tray contains 30 eggs.

Male-headed households are more likely to own improved indigenous chicken breeds, due to their increased capacity to buy them. However, this advantage did not translate into differences in meat productivity among the three household categories (GoK, 2014).

Dairy cow

Dairy cows are mostly reared in the upper (LH2, LH3 and LH4) and middle (LM4 and LM5) zones. The value chain includes both exotic and local breeds; the exotic breeds commonly reared are friesian, ayrshire, and guernsey. The dairy cow population in the County in 2014 was approximately 22,353 with a total milk production of about 26,089,070 litres. Milk production is 6 litres/cow/day which is half of the potential of 12 liters/cow/day.

The sector employs about 21-40% of the population, adult male and female as well as youth. Production is dominated by small-scale input suppliers (since demand for the inputs is low due to high poverty levels among the farmers), processors, retailers and farmers. The average number of animals owned by a farmer ranges between one and four animals.

Productivity is highest among male-headed households during both seasons (see Annex 2) (GoK, 2014), given men's better access to extension services, veterinary services, artificial insemination, dipping, data on climate, and credit. In as much as the female-headed households had better access to some of the services such as research, input and output markets compared to youth-headed households, their productivity is the lowest. Policies relevant to the sector should therefore seek to unlock productivity constraints among the women and promote access to dairy services by the youth.

The major value addition activities include fermenting, making yoghurt and ghee, cooling, and boiling. All these activities except boiling are dominated by women. Value addition is still low as it is mostly done during the wet season when production is high. Factors that contribute to the low level of value addition include lack of know-how and high cost of electricity. The use of solar energy should be explored as a means of reducing the cost of electricity.

Agricultural sector challenges

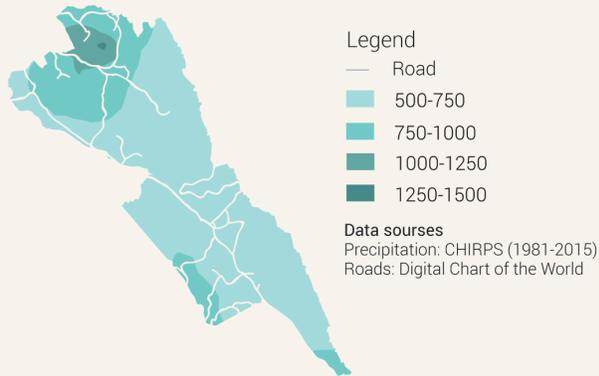
The agricultural sector in Makueni is faced with several challenges. Adding to the fact that the County is largely semi-arid, the sector is adversely affected by climatic variation. Unfavourable climatic conditions such as drought, high temperatures, and poorly distributed rainfall in space and time result in low productivity and frequent crop failures. This has made production of some crops such as maize, coffee, sweet potato, and arrow roots less viable. Young mango and citrus trees, which are less tolerant to drought relative to other crops, have been severely affected. Extreme effects were witnessed in 2016 when several mango and citrus trees dried up throughout the County. Recurrent dry spells and poor yields are disincentives for farmers to adopt new technologies such as use of improved seeds. This reduces the farmers' adaptive capacity to adverse climate. Moreover, farmers lack the capacity to multiply seeds, which explains the scarcity of seeds. This situation is exacerbated by delays in subsidising the purchase of inputs by government. The aridity, low productivity, and difference in planting seasons from the humid regions in the country are some of the reasons mentioned as contributors to delays in providing inputs.

Low production and poor quality of produce arising from harsh climatic conditions pose a challenge to marketing. It was reported that buyers such as hotels in urban areas prefer to buy from middlemen rather than farmers. As such, a large proportion of the farm produce (crops, livestock and livestock products) is sold to middlemen at very low prices. In cases where farmers have production contracts, chances of the farmers dishonouring the contracts by selling to alternative channels offering higher prices are common, due to the disorganised nature of markets. Consequently, some exporting organizations in the green gram value chain have terminated contracts with farmers, exposing them to more market-related risks.

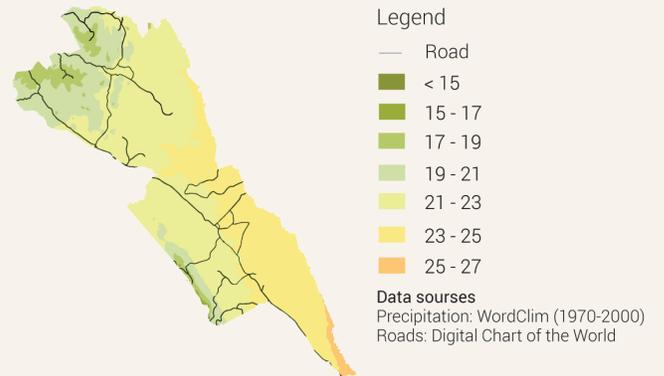
Remoteness of many areas in the County impairs marketing as well, since farmers incur very high costs in transporting the produce to the urban areas where prices are better. Lack of appropriate storage facilities worsens the marketing problem for instance in horticultural crops, making middlemen the only option to whom farmers can sell.

Past and future impacts of climate hazards in Makueni

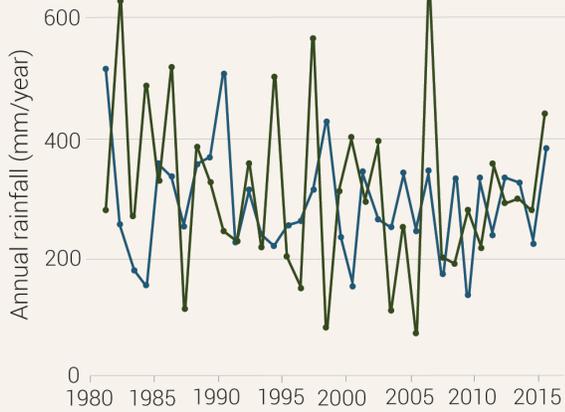
Historical annual mean precipitation (mm/year)



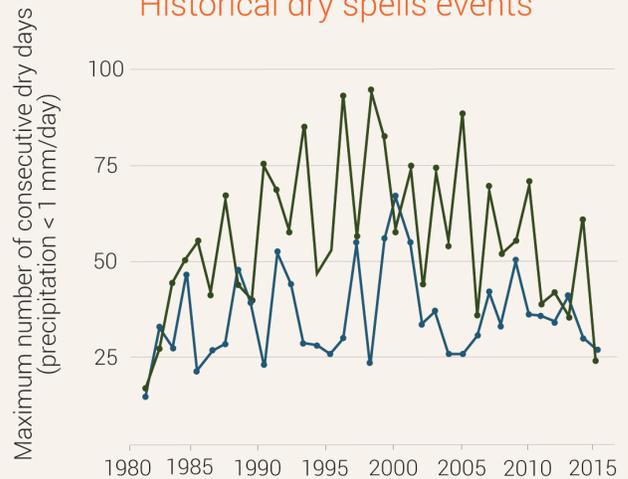
Historical annual mean temperature (°C)



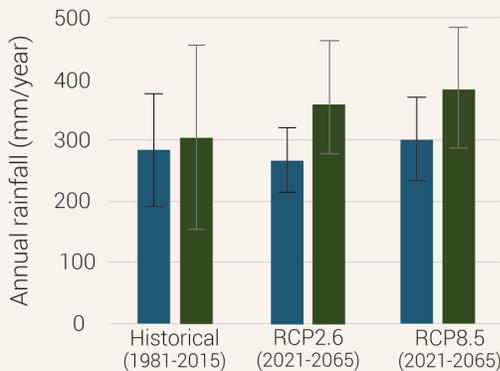
Historical annual precipitation



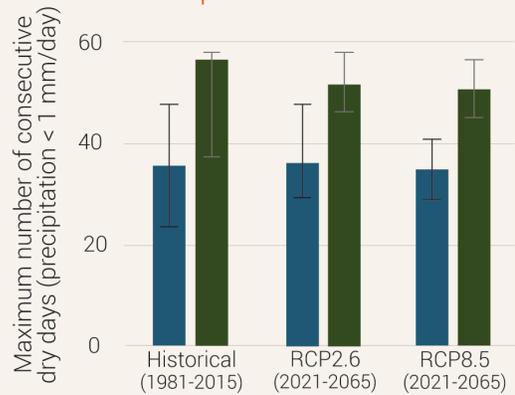
Historical dry spells events



Historical and expected annual precipitation



Historical and expected dry spells events



■ January - June ■ July - December

Some cultural beliefs in the County are detrimental to the agricultural sector. The norm of planting maize throughout the year despite very low productivity increases farmers' vulnerability. The practice persists since households with maize are perceived to be food secure. This belief prevents farmers from venturing into production of crops that are more adaptable to the County's weather conditions. In addition, the belief that use of fertiliser is harmful to the soil has resulted in minimal utilization of fertiliser. Over-utilization of the land with minimal soil amendment and soil erosion by wind and/or water also contribute to the declining fertility, resulting in characteristically low productivity in Makueni.

Poor access to off-farm services such as extension and credit is also an important challenge to the agricultural sector in Makueni. Remoteness of most parts of the County has limited distribution of financial intermediaries, a contributing factor to poor access to credit. Nevertheless, pre-eminence of production risks imposed by harsh weather conditions makes financial institutions shy away from financing farmers in Makueni. On the other hand, farmers never seek financial services due to low awareness and the perceived high interest rates levied by the institutions. Extension services are hard to access due to the low number of government extension workers and high cost of private extension services.

High labour costs impose a serious challenge to the agricultural sector. Rural-urban youth migration is a contributing factor to labour scarcity in the County. Low productivity in the agriculture sector among the youth is a major reason causing them to shun the sector and pursue alternative livelihood activities. The elderly in the rural areas cannot operate modern equipment such as the jab planter, important for soil and water conservation. Consequently, the farmers are continuously using the old farming techniques which lead to more soil degradation since they cannot afford mechanization services. This therefore calls for implementation of measures and policies that can facilitate youth engagement in the sector. Possible pathways include agribusiness training in schools so as to unlock innovativeness in the sector, provision of farm services, inputs and assured output markets. More research should be done to establish the extent to which agriculture benefits from incomes from alternative sources in order to adjust or promote the linkages.

Agricultural production has been negatively affected by climate change/variation. For instance, frequencies of pest attacks and disease prevalence have increased for both crops and livestock. This has made the use of purchased inputs such as pesticides necessary despite the fact that many farmers find them expensive. In the poultry value chain for instance, farmers use traditional treatment methods due to unavailability and high costs of the commercial treatment services, a strategy that may or may not work as was reported. High post-harvest losses due to poor storage methods which come as a result of lack of good storage facilities pose a serious challenge to the agricultural sector. Cases of aflatoxin contamination have been reported in the County. This problem has also been experienced in the government warehouses, where due to lack of a policy governing the management of the storage facilities in the County, not only results to storage problems but also market distortions.

Climate change-related risks and vulnerabilities

Climate change and variability: historic and future trends

Makueni County is fairly hot and dry moderate in temperature throughout, with the exception of a warm and wetter area in the north around Mbooni and the border with Machakos County. This wetter area receives between 750 to 1,250 mm of precipitation and is generally less than 17-21°C on average temperature annually, whereas the vast majority of the county receives 500-750 mm of precipitation annually and is between 21-25°C annually. The first wet season of the year (January-June) tends to be about 1.5 °C warmer. Precipitation falls approximately equal between the first and second wet seasons, but historically the second wet season was more variable from year to year, making it more prone to very high and very low precipitation years. Due to this gradient in climate throughout the county, dry spells, intense precipitation, and heat stress, are all hazards that contribute to agricultural risk in the county.

Historic analysis of weather in Makueni county shows that both dry spells and extreme precipitation are hazards in the county. Dry spells are on average longer during the second wet season averaging close to 50

consecutive days of moisture stress, but ranging from 35 to 80 days in any given year. The first wet season experienced about 35 consecutive days of moisture stress, ranging from about 25 to 60 days in any given year. Extreme precipitation and flood risks are moderate in both seasons, with most years receiving between 20 and 30 mm of precipitation on the wettest day.

Climate has already been observed to change in the county. Since 1981, the first wet season with Predominant high temperature and drought risk has experienced an approximately 10°C increase in mean temperature bringing an associated reduction in crop cycle time and an additional 3-5 days with extreme heat stress (>35°C). Although there was no significant change in precipitation in this season, there was an increase in drought risk due to hotter temperatures. The second wet season experienced a small (< 0.5°C) change in temperature, no increase in heat stress days, and no significant change in precipitation, but continued to be affected by uncertain and highly variable rains.

Looking to the future in the years of 2021-2065, prolonged moisture stress is projected to occur across both seasons of the year analyzed especially for first wettest season, whereas intense precipitation looks to change little. Within 30 years (by the early 2040's) temperature is projected to increase by 0.2°C, with the first wet season projected to experience even greater changes. And by this time, precipitation is projected to increase by 2% in the first wet season, and 17% in the second wet season. Consecutive days of moisture stress is projected to more than double in the first wet season from approximately 60 days to over 80-85 days depending on the amount of greenhouse gas emissions. In contrast, moisture stress in the second wet season is projected to reduce little on average (8 % approximately). However, the second season is projected to receive get more precipitation, and greater extremes in precipitation with climate change. For this season, the single day extreme rainfall is projected to increase by almost 50%. These projections of future climate change under the two climate scenarios - RCP 2.6 and RCP 8.5 - show some small differences, but generally show the same future projections, suggesting climate change impacts will be fairly similar during this time frame no matter the greenhouse gas emissions that occur.

Climate from the farmers' perspective

Awareness about climate change/variation is relatively low among farmers, and for the few who are aware, the knowledge is basic, limited to only daily weather forecasts from radio and TV stations. Most farmers reported to have not received any formal training on climate change, with a negligible number reporting to have obtained climate change related information from magazines such as the "smart farmer". Most of them are therefore oblivious to climatic elements other than drought, which they identified as the major climatic hazard. In spite of the low awareness, farmers ascertained remarkable changes since the 1960s.

Farmers reported that drought spells have increased in frequency since the 1960s, with heat becoming more intense and extreme. This has resulted in several water sources in the County drying up (the Makindu and Umanyi springs). Rivers such as Kaiti, Twake, and Kyusini Kitandi that were once permanent in the 1990s have now become seasonal. In addition, water volumes in the Athi River which flows through the County have significantly reduced. Due to contamination from factories, water has become less suitable for crop and livestock.

Similarly, rainfall amounts have remarkably reduced and are poorly distributed in time and space where areas of Emali, Mbooni, Kilungu, and Kilome receive above normal rainfall (600 mm); mid-Makueni receives below-normal rainfall of 300mm within a very short period. Some areas such as Kibwezi can go for as long as 5 -7 years without rain, unlike in the past. The wetter areas such as the Mbooni and Kilungu hills have been highly populated. Forest cover has drastically reduced in the County as people have encroached on forests in luani hills, Makuli, and Makongo for settlement and charcoal burning. Flash floods have also increased in frequency in Emali, Mukuyuni, and Barazani areas where extreme cases have led to landslides and destruction of roads in Kivani.

Change in climatic conditions has resulted in dominance of new plant species in the County. For instance, the grass species like the African fox tail and the African horse tail that are very palatable and good for beef have been replaced by the less palatable ones such as Sporobolus. Other herbaceous plant species

that are disappearing include the Maximum Suave, Oxalis, Leuceana, Glycin Whight (suitable for goat) and some wild fruits (not identified at time of interview). Temperatures have generally increased and reached extremes in the recent years, with very low temperatures in the morning and evening, and very high temperatures during daytime. The extreme temperatures and dry spells have been reported to contribute to more pests (like white ants) and disease prevalence for both livestock and crops. Diseases such as Newcastle, Coccidiosis, Fowl pox, Chicken flue and Gumboro for chicken, Rift Valley Fever (RVF) and pneumonia for cattle, goat and sheep have become more pronounced. Mango fruit fly has become more stubborn to pesticides and was reported to be a menace in 2016 in many parts of the County.

Climate change/variation has been associated with negative impacts to society. The high food insecurity, low farm incomes and high poverty levels characteristic of the County have been associated with low agricultural production largely caused by the harsh climate. The rate of children dropping out of school and youth engaging in illegal income-earning activities have significantly increased due to food scarcity. Dependency on food aid and school feeding programmes has become common in the County as well.

Climate vulnerabilities across agriculture value chain commodities

Makueni ranks among the counties most vulnerable to climate change, with a vulnerability index of 0.437 (GoK, 2013). Seventy-five percent of farmers have reported experiencing climate change in form of reduced yields and 95% in form of frequent and prolonged droughts (Richard et al., 2012). Drought affects the agricultural sector greatly throughout the County especially in AEZs LM4, LM5 and IL6, whereas floods affect the hilly areas such as Kilungu, Mbooni and Kivani (AEZ UM2, LH2 and UM3). Potential future hazards relevant to the four major VCCs were identified as moisture stress, drought, increased temperature, and heat stress¹⁰. These hazards are already evident and impact the major value chains differently.

Green gram

The green gram value chain is adversely affected by mainly drought and moisture stress. These hazards affect all the stages in the value chain, from production to output markets. The key activities in the green gram value chain that get impaired by these hazards were identified as: seed, fertiliser and pesticide acquisition in the input supply stage; land acquisition, land preparation and weeding and harvesting in the on-farm production stage; threshing/winnowing, sorting/grading, and storage in the post-harvest stage; and pricing, selling and market linkage in the output markets stage.

Drought and moisture stress not only result in a reduction in cultivated area but also yields and quality of the produce. Production costs also go up during drought and heat stress periods since more labour is required to carry out activities such as sorting, owing to the poor quality, and hired labour arising from inadequate draft power supply. During this period, the animals used for land preparation and weeding are too weak to work. The remarkably increased youth migration to urban areas in search of employment worsens the situation, as older farmers left behind are not able to adopt the existing adaptation strategies such as conservation agriculture due to high costs and lack of labour.

Production of small volumes challenges marketing, as demand is not achieved. In addition, lack of proper storage facilities exacerbates the problem as it impairs collective marketing. For instance it was reported that in 2016 5,000 bags of green gram were rejected by a buyer due to contamination during storage, resulting in huge losses to farmers in Kilili.

Local poultry

Local poultry are mainly affected by drought and increased precipitation. The key activities along the value chain were identified as acquisition of breeding stock, feeds, drugs, and housing material for the input supply stage, feeding, vaccination and breeding for the on-farm production stage, collection and transporting in the post-harvest stage, and selling and promotion in the output marketing stage.

¹⁰ These hazards were identified in a workshop where participants were presented with two probable future scenarios (the most extreme) and asked to rank the indices in each scenario most problematic to a certain value chain.

High precipitation leads to increased demand for veterinary services as it causes an upsurge of diseases, destroys chicken housing leading to high chicken mortality rates and increased demand for housing construction material. The hazard also impairs transportation of the products due to destruction of roads. On the other hand, drought results in scarcity of feeds and as such farmers are required to depend on purchased feeds which are expensive. Due to feed scarcity, conventionally farmers reduce stocks and sometimes leave the birds to scavenge. The two hazards are associated with a reduction in egg production, a factor that is problematic to marketing since more time and money are spent in collection of eggs and breeding. Reduced egg production and increased chick mortality impair breeding and require farmers to source for breeding material from the Kenya Agriculture and Livestock Research Organization (KALRO) at Naivasha. Establishment of breeders within the County is a possible way of solving the problem.

In addition to the on-going adaptation strategies to combat the impacts of the hazards such as use of manure instead of fertiliser, conservation agriculture (though not all farmers are able to afford it), use of traditional pest control methods, kitchen gardening, irrigation and selling at farm gate, several potential strategies that can be sought in the future were identified. Among these were upscaling of conservation agriculture to reach all farmers, cooperate purchasing of inputs such as fertilisers and pesticides, promotion of irrigation and mechanization, and construction and proper management of collection and storage facilities.

Low incomes, lack of skills in poultry production, low technology adoption, and expensive inputs such as feeds are some of the factors that are making farmers adapt poorly to these hazards. Therefore, measures that can improve the adaptive capacity of the farmers like facilitation of access to credit, training on feed formulation, and promoting availability of improved chicken at affordable prices should be implemented. In addition, the feed problem in future can be handled by construction of a feed processing plant in the County, the marketing problem through venturing into development of online marketing platforms and lack of breeding material through establishment of a research station on breeding in the County.

Dairy (cow)

The most problematic hazards for the dairy sector were identified as high temperature and heat stress. These hazards affect important activities in dairy production, which include acquisition of feeds, veterinary services, and extension at the input stage and feeding, breeding and cleaning of structures at the on-farm production stage. The key activities at the post-harvest stage are storing, transporting, and bulking, whereas at the output markets pricing, selling and promotion are the most important.

High temperatures and heat stress result in reduction in feed quantity and quality, hence farmers opt to use concentrates. It was reported that due to lack of information the farmers end up using the wrong ratios. Demand for commercial inputs goes up during times of high temperatures and heat stress hence increasing production costs. Unavailability of feeds also makes the animals more susceptible to disease hence requiring more veterinary attention.

Milk production is negatively affected by the hazards since the animal spends more energy in temperature regulation rather than milk production, more so during heat stress. The hazards were also reported to cause disruptions in the oestrous cycle resulting in silent heat, a factor that impairs breeding. In addition, the quality of the milk is negatively affected. These factors pose a challenge in marketing and collection (bulking) due to production of small quantities and reduction in the shelf-life.

Adaptation to these hazards is very low. The on-going strategies such as rearing improved breeds, feed conservation, use of Artificial Insemination in breeding, collective marketing and value addition (mainly boiling and cooling) are limited to the farmers with know-how on for instance feed conservation and those that have financial resources. As such, future efforts in improving adaptability should aim at training the farmers on feed conservation, providing cheap extension and exposing them to new production methods. This should be contemporaneous with improving credit access for the farmers so as to enable them to adopt the interventions.

Other technologies such as the use of sexed semen could be pursued in the County. Cooperatives should be provided with tankers for transporting milk, and farmers with aluminum containers so as to reduce contamination as well as increasing the shelf-life.

Mango

In the mango value chain, heat stress and high temperatures are reportedly the most problematic. These hazards impair key activities in the value chain such as acquisition of pesticides, seedlings, and land at the input stage, and land preparation, planting and spraying at the on-farm production stage. Key activities at the post-harvest stage are collection, transporting and processing, whereas at the output market stage, selling, promoting as well as linking farmers to markets were identified as the most important.

High temperatures and heat stress have minor effects on fertilisers, as they cause minor deterioration in quality. Conversely, the impact is major on seedlings, leading to poor quality and hence low establishment when it comes to on-farm production. Farmers are adapting to these hazards at this stage by stocking fertilisers through cooperatives, establishing mango nurseries, and utilizing water-efficient seedling varieties. Potential adaptation options include utilization of manure to counter deterioration of fertiliser quality as well as burning effect on the crop, and establishment of community commercial nurseries for mango seedlings. The hazards do not have a significant effect on land acquisition, since farmers never seek to lease land during drought. Practices such as agroforestry and soil and water conservation can help rehabilitate land and enable farming even when there are high temperatures and heat stress.

Less pesticides are utilized when hazards hit (mainly due to water scarcity), hence increasing the chances of attack by pests and diseases. Farmers restrain from spraying during dry spells to avoid contamination especially for exported mango. In addition, the pesticides are less effective during this period as they only remain on the surface for lack of water. As a result, alternative measures include use of Integrated Pest Control (IPM) though this is still a new measure that has not been taken up by many farmers. The impact on planting is major, as most of the seedlings dry up and hence increase establishment costs. This has led to farmers using approaches such as irrigation and more manure to increase the survival rate of the seedlings.

It was reported that the quality as well as quantity of the mango harvest decrease due to these hazards, therefore posing a challenge on post-harvest activities such as collection, transporting, and even processing. Due to the poor quality the shelf-life is drastically reduced

hence high costs are incurred during transportation. The high temperatures require farmers to transport the mangoes at night as an adaptation mechanism. This requires County and other stakeholders to invest in transport through for instance purchasing trucks with coolers.

Adaptation to climate change and variability

Climate hazards in Makueni have led to adoption of a number of on-farm adaptation strategies and off-farm services intended to increase the adaptive capacity of the farmers. About 92% of households use at least one of the adaptation strategies, with about 84% of the farmers responding to late onset of rains (Mwangangi et al., 2012). Adoption of the adaptation strategies is highest among youth-headed households and lowest among female-headed households¹¹. This is notwithstanding the fact that more female-headed households had received climate change training compared to both male- and youth-headed households (46%, 36% and 30% respectively) (GoK, 2014). The likelihood of the youth being more open to new ideas and technologies explains the high adaptation rates. High literacy levels and resource availability for men are some of the factors that explain the high adoption rates among men compared to women (Bernier et al., 2015). In addition, women were reported to be more risk-averse compared to men and youth.

In addition to the high poverty levels which deprive farmers of required capital to adopt some of the adaptation strategies, lack of knowledge and capacity in value addition, fodder and feed conservation, poor farmer organization, cultural practices such as minimum utilization of inputs such as fertiliser and poor road network reduce the adaptive capacity of farmers. Institutional factors for instance insecure land tenure given that only 20% of all land owners have title deeds (GoK, 2014) hinder long-term adaptations like water harvesting and agroforestry.

On-farm adaptation practices

Adaptation strategies in the livestock sector include fodder production and feed conservation to ensure feed availability, use of simple treatment methods such as deworming, dehorning and hoof trimming, use of drought-tolerant grass varieties and use of water baths

¹¹ According to the ASDSP, adaptation of adoption strategies is highest among youth- compared to male- and female-headed households. This might be misleading since the small sample size for the youth-headed households may not be sufficient enough to enable inferencing for the entire population.

for cooling, use of charcoal and firewood as energy sources for boiling milk, and use of cheap transport means like donkeys. On the other hand, adaptation strategies for crop farmers include change of planting calendar, use of drought-tolerant crops, seed recycling, use of manure instead of fertiliser (crops under manure are allegedly more resilient to drought than those under inorganic fertiliser), conservation agriculture, irrigation and home nurseries for example for the mango value chain. Common strategies to both livestock and crop farmers include water harvesting, tree planting and agroforestry.

Tree planting ranked first in terms of proportions of households practicing on-farm adaptation options (Richard et al., 2012; GoK, 2014). This option is common in AEZs, LM4, and LM5 which constitute about 75% of the arable land in Makueni (Maluki et al., 2016). The high adaptation can be associated with the County efforts to promote the activity through the greening programmes in urban areas and schools, where drought-tolerant tree species such as *Mellia*, *Thevetia Peruniana* and *Euphorbia Triculi* are being promoted. This adaptation strategy does not only promote soil and water conservation but it's also a potential adaptation strategy for dairy cow farmers in providing raw materials for construction of various structures. Limited access to land by the youth and women poses a challenge in adopting the strategy for the two groups.

Approximately 65% of the youth- and female- headed and about 57% of the male-headed households practice crop changing (GoK, 2014). Mwangangi et al. (2012) observed that crop changing was mainly in response to market (97% of the households) and land (91% of the households) issues. Farmers are slowly shifting from production of crops such as maize and sweet potato to production of drought- tolerant crops such as green grams, citrus and pigeon peas. This is attributed in part to promotion of the drought-tolerant crops through provision of improved seeds as well as linkage to markets by organizations such as the Food and Agriculture Organization (FAO), the Farm Input Promotions Africa (FIPS) and the MoALF. Nevertheless, the culture of minimal input utilization, poor response to off-farm services such early warning information by farmers and high poverty levels are some of the contributing factors to low adoption.

Soil and water conservation measures such as conservation agriculture, water harvesting (construction of sand dams, zai pits, road run-off harvesting, and farm ponds among others), cover crops, and terracing are popular in AEZs LM4, LM5

and LM6. Here approximately 53% of the households are using at least one of the strategies. Adoption of these strategies was found to be highest in the youth-headed households compared to both the female- and male-headed households (71%, 56% and 50% respectively) (GoK, 2014). Some of these strategies are labour intensive, hence the high number of youth practising them relative to the other age groups.

Thirty-five percent of the households practising value addition as a strategy are headed by youth and 21% are headed by female farmers (GoK, 2014). Value addition, which is done in all the AEZs include activities such as collection, transportation, bulking, and cooling and boiling for milk. The strategy helps in solving problems such as lack of proper storage facilities, poor prices and reduction in the shelf life of commodities like milk when temperatures are high. Value addition in the County is generally minimal across the four major value chains. This might be due to the production of small volumes (which never leads to over-supply in the markets) as a result of harsh climate, consumption of produce while in the field due to food insecurity, lack of capacity in terms of knowhow and capital, and poor electricity infrastructure.

Transport becomes scarce especially during periods of increased precipitation; however, farmers circumvent this problem by using cheaper transport such as donkeys. Lack of storage facilities for products like milk has prompted farmers to use methods like boiling using charcoal and firewood as sources of energy to increase the shelf life. During periods of high temperatures, they cool the milk using water baths, shed nets, and charcoal coolers.

In the livestock sector, on-going strategies such as rearing improved breeds, feed conservation, artificial insemination in breeding, collective marketing and value addition (mainly boiling and cooling) are limited to the farmers with know-how and those that have financial resources. Youth-headed households have a 23% likelihood of adopting feed conservation than the male- and female headed households (20% and 17% respectively) (GoK, 2014). In the poultry value chain, farmers in the hilly areas respond to scarcity of feeds by purchasing commercial feeds whereas those in the low areas practise free range.

In response to unavailability of planting and breeding materials, farmers engage in establishment of home nurseries for crops such as mango, and seed recycling in the other crops such as green gram. For cattle, the conventional use of bulls for breeding is the commonly used method. These methods are not adequate due

for instance to transmission of diseases through the use of bulls for breeding. Seed unavailability is never adequately addressed through seed recycling due to utilization of all harvested seeds for consumption given the high likelihood of failure of maize.

Utilization of manure was also identified as a common practice in all the AEZs for crop production. Farmers use manure in lieu of fertiliser due to high prices, unavailability of the fertiliser and the preference for manure to fertiliser. Preference for manure is due to the fact that crops under manure are more resilient to drought compared to those under fertiliser.

Low incomes, lack of skills in poultry production, low technology adoption, and expensive inputs such as feeds are some of the factors that are making farmers adapt poorly to climate hazards. Therefore, measures that can improve the adaptive capacity of the farmers, such as facilitation of access to credit and extension, training on feed formulation and conservation, and promoting availability of improved breeds and seeds at affordable prices should be implemented. In addition, the feed problem in future can be handled by construction of a feed processing plant in the County, while breeding challenges could potentially be addressed by establishing a research station on breeding in the County.

Off-farm adaptation practices

To enhance farmers' capacity to adapt to climate change risks, various organizations offer off-farm services in the County. Some of the services offered include extension, Early-Warning Information System (EWIS), market linkages, finance services, provision of inputs such as seeds for both crops and pastures, and disease surveillance.

Institutions such as MoALF, United States Agency for International Development (USAID), and the Food and Agriculture Organization (FAO) offer farmer trainings on crop selection, encouraging the planting of drought-resistant and early-maturing crops such as green gram, use of improved seeds, value addition, and development of groups to facilitate market access, information, and credit. However, the main limitation to extension services is understaffing (few extension agents from both government departments and Non-Governmental Organizations [NGOs]).

Extension services on conservation agriculture, which includes methods for soil and water conservation (mulching, crop rotation, minimum tillage, and strip-

cropping) are normally offered by the Agricultural Mechanization Services (AMS), a wing of the MoALF, and FAO (under the Conservation Agriculture Program). The services offered include provision of CA equipment as well as leasing at very low cost (KES 1,500, compared to the conventional KES 4,500 per acre), training on CA and promoting utilization of biogas and energy-saving jikos. So far, farmers practising CA have reported remarkable increases in productivity, from 2.5 to 12-15 bags/ha for green gram. Challenges facing access to the services include high cost implications for most farmers and inadequacy of machinery due to high duty on importation.

Another important off-farm service that farmers access in the County is the EWIS, offered by the County, the Kenyan Meteorological Department (KMD) and the NDMA in collaboration with the MoALF. This system involves publication of a brochure that informs farmers on upcoming weather changes in the three agro-ecological zones in the County. In addition there is a daily weather update, where about 3,800 farmers receive messages via Short Messaging Service (SMS) a programme that is supported by the United Kingdom Department for International Development (DFID). Major challenges reported in offering these services include financial limitations, language barrier (the brochures are in English only), and network problems which impair operation of the SMS services. Translation of the brochures to the Kamba language would facilitate information dissemination.

Financial services in the County are offered by various financial institutions such as banks (KCB and Equity among others), insurance companies and cooperatives (Universal Traders Limited [UTL]). Some of the packages offered by the UTL in collaboration with the Netherlands Government, FAO and the USAID include Mkulima Bora, which mainly deals with horticultural crops and Mkulima Halisi that deals mainly with green gram. The institution also offers loans to farmers to enable them purchase fertilisers and pesticides from identified agricultural input dealers like Bayer Chemicals, Osho Chemicals and Syngenta as well as undertake irrigation projects. Challenges in delivering the financial services include high default rates due to frequent crop failures, a factor that impairs sustainability of the credit programmes. In addition, many farmers never seek for credit partly due to a negative attitude from the perception that the financial institutions take advantage of farmers. This is despite the fact that the interest rates for the capital borrowed is only 9%.

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

Dairy (cattle)



High Temperatures

Reduced feed quantity and quality; water shortage; increased incidences of animal pests and diseases

Animal heat stress; reduced animal weight gain and reproduction; irregular heat cycle; cattle spend more energy to regulate temperature; increased costs of production for milk cooling

Reduced milk production; reduced milk quality; high milk spoilage

Inadequate volumes for processing and marketing; low milk sales

Magnitude of impact

Minor-Major

Minor-Major

Minor-Major

Minor-Major

Farmers' current strategies to cope with the risks

Conserve fodder through silage and hay bailing; use of certified vaccines

Use of locally-sourced bulls for breeding; awareness of simple husbandry practices (hoof trimming, dehorning, deworming)

Pre-cool milk before transportation using shade nets, charcoal coolers and water baths; use of charcoal and firewood as energy sources for boiling milk; use of coolers

Dairy cooperatives and individual farmers set the prices; use of milk bars as selling points; selling milk from collection centres

Other potential options to increase farmers' adaptive capacity

Introduce drought tolerant grasses and fodders; invest in extension services; increase use of low cost systems for pastures conservation (silage, hay)

Use mixed rations to supplement feed; use early heat and pregnancy detection tests to improve conception rates; use of disinfectants during cleaning; silvopastoral systems

Transport milk in cooled tankers; value addition of milk through packaging and processing; pasteurized milk; use of biogas to provide energy

Improve milk pricing through contract farming; provide financial loans to equip local milk producers; introduce agricultural shows/exhibitions in the county

Mango



High Temperatures

Reduced seedling vigour; increased incidences of pest attack; reduced soil moisture

Reduced productivity, increased flower abortion; delayed flowering; poor plant establishment; uncontrolled use of banned pesticides (not approved); reduced tree growth rate and vigour

Reduced fruiting and fruit yields; reduced plant population; low fruit quality harvested

Low aggregation of fruits at local markets; low prices due to poor quality; reduced product shelf life- fruit rots in storage

Magnitude of impact

Major

Major

Moderate

Farmers' current strategies to cope with the risks

Increased surveillance of stockist to ensure stocking of approved pesticides; supplement soil moisture using water harvesting technologies; soil conservation, agroforestry, conservation agriculture

Use drip irrigation, water harvesting, mulching/use of manure; use early land preparation, conservation agriculture

Transport mangoes at night to avoid fruit deterioration in high day temperature; county government subsidy for transport of mangoes; cottage industries set up for local fruit processing

Use contract farming to improve aggregation and pricing; formation of groups for collective marketing and pricing; early market scouting and setting of price with dealers

Other potential options to increase farmers' adaptive capacity

Introduce Integrated pest management (IPM) and crop management techniques to support commercial fruit production; install large water harvesting farm ponds

Create local schemes to support and improve farmer's capability in Good Agricultural Practices (GAPs) to meet global market needs; crop diversification; agroforestry systems

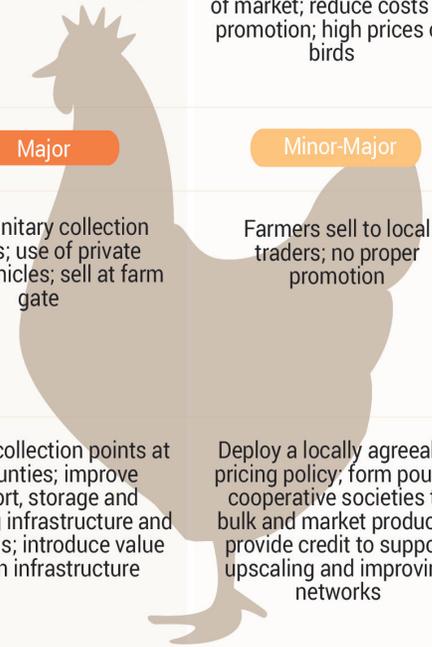
Design and install fruit holding containers with cooling facilities; transport in trucks with cooling systems and using fruit crates; local value addition into diverse mango products

Conduct market survey to establish market needs and opportunities for farmers; provide credit facilities for local mango trading and transport entrepreneurs

Poultry (local)



 <p>Increased precipitation</p>	<p>Reduced quantity and quality of local feed materials for processing farm poultry rations; damage poultry housing; renders road infrastructure impassable</p>	<p>Escalated incidences of poultry diseases; increased frequency and cost of vaccination; stunted growth and reduced production; high costs of production</p>	<p>High mortality rates; low egg production; increased perishability</p>	<p>Poor linkages as a result of low volumes of sales; low egg prices; delayed access to markets</p>
<p>Magnitude of impact</p>	<p>Moderate-Severe</p>	<p>Major-Severe</p>	<p>Major</p>	<p>Moderate-Severe</p>
<p>Farmers' current strategies to cope with the risks</p>	<p>Use of charcoal burners to provide heat in poultry house; timely vaccination against common diseases</p>	<p>Practice free range; supplement using commercial feeds; reduce flock size through culling; use of herbal formulations to treat common diseases</p>	<p>Ensure ventilation of the products during storage and transport</p>	<p>Reduced linkages due to low volumes; willing seller willing buyer agreement at farm gate</p>
<p>Other potential options to increase farmers' adaptive capacity</p>	<p>Design and build modern poultry houses with appropriate and safe lighting, ventilation and heating systems; develop appropriate vaccines and vaccination regimes; introduce local improved poultry breeds</p>	<p>Build farmers capacity in feed ration formulation from local resources; disseminate appropriate vaccines and vaccination regimes; build farmer capacity in management of introduced poultry breeds</p>	<p>Improve on-farm feed storage facilities; improve road infrastructure</p>	<p>Enhance feed production and storage; provide credit facilities to support poultry production; introducing pricing based on determined weights</p>
 <p>Droughts</p>	<p>Poultry feed and water scarcity; heat stress on chicks; poor poultry house ventilation; reduced breeding</p>	<p>High cost of feed to supplement available feeds; reduced and stunted growth rate; increased costs in chick management to avoid mortality</p>	<p>Low egg production; increased chick mortality</p>	<p>Inadequate supply of eggs to the markets, loss of market; reduce costs of promotion; high prices of birds</p>
<p>Magnitude of impact</p>	<p>Major-Severe</p>	<p>Major</p>	<p>Major</p>	<p>Minor-Major</p>
<p>Farmers' current strategies to cope with the risks</p>	<p>Use locally available materials to construct poultry houses; use improved breeds and breeding stock from KALRO NAIVASHA; purchase drug from local agro-dealers and service providers</p>	<p>Leave birds for scavenging; use of herbs formulations to treat diseases; use of vaccination on a small scale</p>	<p>Communitary collection centres; use of private motor vehicles; sell at farm gate</p>	<p>Farmers sell to local traders; no proper promotion</p>
<p>Other potential options to increase farmers' adaptive capacity</p>	<p>Establish breeding stock facilities within the county; design and disseminate vaccination programs; establish woodlots to supply construction materials</p>	<p>Build local capacity in feed formulation, water harvesting and storage; practice semi intensive rearing; use improved technologies e.g. in incubation; serial/synchronised hatching</p>	<p>Establish collection points at sub counties; improve transport, storage and processing infrastructure and regulations; introduce value addition infrastructure</p>	<p>Deploy a locally agreeable pricing policy; form poultry cooperative societies to bulk and market products; provide credit to support upscaling and improving networks</p>



Green gram



	Provision of seeds and other inputs	On-Farm production	Harvesting storage and processing	Product marketing
 Reduced rainfall	Soil moisture stress; shifts in planting dates and plant maturity period; increased costs of inputs and labour for land preparation (weak draught power)	Reduced vegetative growth, wilting; flowers abortion; early shattering of pods; crop failure	Reduced yields and quality; poor post handling storage and processing, winnowing, sorting; increased post-harvest costs of labour (low volume, disease infested produce)	Poor market linkages due to low volumes produced; low farm gate prices due to low quality produce
Magnitude of impact	Moderate	Moderate	Moderate	Major
Farmers' current strategies to cope with the risks	Use of drought tolerant varieties; recycle seed from previous cropping seasons; capacity building of producers on use of fertilisers both organic and inorganic	Conservation agriculture	Use labour intensive post harvest methods like winnowing, air drying"	Grain banks at farm community level
Other potential options to increase farmers' adaptive capacity	Introduce varieties with efficient moisture use; use available nutrient resources such as manure	Ensure access to land for production through land subdivision; promote irrigation and water harvesting techniques; crop rotation; minimum tillage; cover crops	Bulk commodity through societies to benefit from economies of scale; construct storage facilities equipped with post harvest machines at community level; introduce policy measure to subsidize investment in mechanisation	Contract farming opportunities
 Droughts	Reduced animal draught power due to weak animals; reduced capacity to purchase inputs	Late land preparation and less area ploughed; low use of improved varieties and fertilizers	Low volumes; yield loss	Poor market prices; loss of income
Magnitude of impact	Moderate	Moderate-Major	Severe	Severe
Farmers' current strategies to cope with the risks	Use new adapted seed varieties; seed production; use of animal manure	Access land through leasing, sub division of land; use conservation agriculture and water harvesting practices; use of herbicides; use of draught power; conservation agriculture; cover crops	Manual threshing and winnowing; manual sorting; manual dusting and packaging	Sell at farm gate, some aggregate and sell as groups; scouting to identify for best market for produce
Other potential options to increase farmers' adaptive capacity	Introduce water use efficient varieties; develop fertilizer recommendations based on local soil tests	Encourage land adjudication and sub division to ensure access and use of land; Mechanisation e.g. planters	Set up facilities for mechanical threshing, winnowing, grading and packaging; warehouse reseed system and storage facilities	Form cooperatives to aggregate and bulk purchase of inputs; initiate credit facilities for bulk input purchase; introduce policy measure to improve available marketing

Policies and Programmes

A number of policies and acts have been enacted in the County in response to climate challenges. Makueni is the only County in Kenya with a Climate Change law incorporated in the County Integrated Development Plan (CIDP). The County Climate Change Fund (CCCF) of 2015 stipulates 1% of the County budget to be devoted to climate change interventions. Under the law, the County has also established a County Climate Change Fund Management Board (CCCFMB) to manage the Fund (GoKb, 2015). The initiative has enabled stakeholder engagement in identifying crucial climate-related interventions and public sensitization on climate change. Considering this milestone in addressing climate change, a climate change policy that can comprehensively guide the intervention and promote coordination and collaboration among various actors is lacking. This has resulted in an overlap in interventions, a factor that is worsened by the fact that not every stakeholder in the County is a member of the County Environment Committee (CEC)¹².

The Sand Conservation and Utilization Act of 2015, enforced by the County Sand Authority (CSA) seeks to regulate and ensure sustainable and equitable utilization of sand (GoK, 2015). The Act borrows from the Environmental Management Coordination Act (EMCA) of 1999, a policy that addresses environmental matters at national level. Sand is an important natural resource since it is not only a source of income but also determines the success of interventions such as sand dams. On this account, uncontrolled harvesting can impose serious ramifications, for instance reduction of the water holding capacity of water reservoirs. The CSA collaborates with the National Environment Management Authority (NEMA) in issuing licenses for sand harvesting. The CSA has succeeded to a small extent in regulating sand harvesting and hence benefited the local people. Nonetheless, political interference and lack of an environmental policy in the County are some of the impediments to effective enforcement.

Other relevant acts and policies that were identified include the Water Act of 2002, the Forest Act of 2005, Wildlife Conservation and Management Act of 2013, Forest Policy of 2014 and the National Land use Policy of 2009. The above-mentioned policies are at national level, making enforcement a challenge. For instance, despite devolution of the water department, the national Act does not clearly outline the responsibilities to be undertaken by the different County offices. This gap challenges management of shared watersheds. Similarly, the Land use Policy does not fully address land matters at the County level considering that surveying and mapping of the County was done

several years ago, and only about 20% of land owners have title deeds. This is despite the efforts by the County government to digitize and demarcate pasture, farming and wildlife lands (GoK, 2016). Insecure land tenure has been reported to impair climate-related interventions such as construction of sand dams (Evenson and Pingali, 2007, p2926).

Enforcement of the Wildlife Conservation and Management Act is impaired by lack of clear land demarcation. Cases of human-wildlife conflict are common especially during dry periods as wild animals from Tsavo National Park stray into farms. Compensation for the damage caused by the wild animals is a challenge in spite of an elaborate outline of the process in the Wildlife Conservation and Management Act. Fraud due to political influence was reported as one of the contributing factors to inefficient enforcement.

In addition to the policies, several programmes are being implemented (either by a single organization or in collaboration) to directly respond to climate change threats as well as improve farmers' adaptive capacity. Most of the programmes identified revolve around drought management, and they include: the Soil and Water Conservation for Crop and Pasture Production, Njaa Marufuku, Food for Asset program, Environment awareness Program, Early Child Development Feeding programs, Conservation Agriculture, the Greening Program, Miti Mingi Maisha Bora, Kenya Agricultural Value Chain Enterprises, and the Natural Resource Management Programme.

The Agricultural Sector Development Support Program (ASDSP), supported by the Kenyan and Swedish Governments in 2010 was established with the goal of transforming Kenyan agriculture to a commercially-oriented sector as a pathway to reducing poverty and food insecurity. In Makueni County, the programme promotes capacity building and acts as an avenue that brings together various stakeholders in the agricultural sector such as farmers and government departments. It has also managed to link farmers to markets. For instance, mango farmers have been linked to exporters such as KEIT, Antennae, Green World, Waquash, Fronco and Jacal, and processors like Makiyika Mango processors and Huruma Asili.

The Kenya Agricultural Productivity and Agribusiness Program (KAPAP), which is the second phase of the Kenya Agricultural Productivity Program (KAPP) that was started in 2004 by the Kenyan Government and the World Bank, has facilitated several farmer trainings on issues such as soil conservation and fertiliser and pesticide use. It has also enabled farmers to adopt climate risk adaptation strategies such as value addition in the mango value chain

¹² The CEC brings government departments and other selected organizations together to discuss environmental matters.

by contributing to construction of the Kalamba Mango processing plant and water harvesting.

Some of these programmes have registered success. The success is partly attributed to the fact that most of the programmes are targeting group members in order to facilitate coverage. For instance, the Adult Literacy programme that is implemented by the World Bank targets women in groups. Through this approach it has been able to increase literacy levels among old people in the County. Similarly, the Conservation Agriculture programme that is being implemented by FAO has so far reached 480 farmer groups¹³. The Cash for Assets (initially Food for Assets) implemented by the Red Cross, World Food Program (WFP), World Vision and the National Drought Management Authority (NDMA) has been able to not only link farmers to markets but also enlightening them on climate-smart agricultural practices in areas such as Kalowe and Kibwezi, where about 61,000 farmers have been reached.

Despite success, several factors were reported to challenge full realization of programme objectives. Such challenges include insufficient funds to enable wider coverage, poor road network and insufficient staff. Some cultural practices such as continued maize production, low fertiliser use, high dependency syndrome compounded with high poverty levels impair success and ownership of most of the programmes. In addition, it was reported that these programmes are not well coordinated, and hence a lot of duplication can be observed. For instance, it was observed that the County government as well as the NDMA engage in providing weather forecast brochures independently. Coordination in construction of water harvesting and conservation structures, an intervention undertaken by several organizations in the County, is low. Factors such as minimal involvement of all stakeholders at all programme/project phases and lacking policies were the reasons identified as contributing to poor coordination.

Governance, institutional resources, and capacity

A number of government, non-government, and community-based, private and faith-based organizations have a direct or indirect involvement in abating and/or mitigating climate risks in the County.

Anglican Development Service Eastern (ADS) is a NGO undertaking interventions in linking farmers to input suppliers, capacity building where the organization is

currently working with about 40,000 farmers under the KAVES programme, and promoting value addition for milk through production of yoghurt in Kathonzweni and Kikima. ADS is also promoting tree planting and improved varieties for sorghum, finger millet and cowpea. For instance, through tree planting promotion activities, 1,500 households have managed to plant trees in their homesteads. The organization has collaborated with (USAID, the Alliance for a Green Revolution in Africa (AGRA), the Anglican Board of Mission (ABM), Bread for the World, Christian Aid, NDMA, Transform Aid International, Land O'Lakes International, and government institutions such as NEMA and NDMA and the County Government. Interventions by the organization are guided by donor requirements, though selection of intervention approach, location and beneficiaries are informed by desk reviews, baseline surveys and recommendations from stakeholders. Implementation of interventions is mainly done by the staff and sometimes with the collaborators.

Other NGOs working in the County include the Business Initiative for Survival and Eradication of Poverty (BISEP) and Pathways to Resilience in Semi-Arid Economies (PRISE). BISEP enhances capacity building among farmers by identifying gaps in various value chains and addressing them such as linking farmers to markets, promoting value addition, collaborating with research organizations and technology dissemination. For the case of value addition, mango and indigenous vegetable (cowpea) farmers have been capacitated to do sun-drying. BISEP reported to involve all stakeholders in all their undertakings, beginning from project inception to implementation. Nevertheless, sometimes donors dictate on the objectives and scope of interventions. PRISE on the other hand is a research organization undertaking research on subjects such as climate change.

The County Government of Makueni, through the Environment office, implements and facilitates a number of climate-related interventions. This has been enabled by the CCCF. Some of the interventions include sand dam construction (such as the Mito Andei Sand dam), water harvesting and greening programme through tree planting that targets urban areas and schools. The County Environment office also creates environmental awareness through educating people at ward levels. Participants are also called upon to prioritize intervention points which are then approved by the CEC. In addition, celebration of the World Environment Day acts as an avenue for public sensitization on the environment and practices such as conservation agriculture.

13 These farmers were trained by Trainer of Trainers initially trained by FAO.

For the case of the devolved government departments, funding is mainly from the national government, channelled through the County government. As such objectives are mainly set from the national offices with consultation from the County offices, which take part in customizing the plans for the County. Nonetheless, some government organizations such as NDMA reported having autonomous control on the nature of interventions they undertake.

It was reported that lack of a policy regulating climate change interventions is the number one reason for poor coordination and collaboration. This factor creates loopholes for political interference in implementing the interventions. Lack of trust among the various actors leads to withdrawal from disclosing full intervention information to collaborators. Other factors hindering coordination and collaboration include inadequate staff, lack of technical know-how and insufficient funding which comes as a result of donor fatigue. In addition, recent international events such as the Brexit are foreseen to impact negatively on funding for many of the organizations operating in the County such as FAO. Some of the suggested ways of addressing low coordination include enactment of a policy governing coordination, increasing stakeholder consultations as well as creating a body with the sole mandate of overseeing climate change-related interventions.

Synthesis and Outlook

Climatic hazards such as drought, high temperatures and moisture stress are not new in Makueni given that the County is located in the Arid and Semi-Arid Lands (ASAL) region. As these hazards are foreseen to occur more frequently in the future due to climate variability, enhanced capacities of farmers to cope with these new conditions are pertinent. This involves critical short-term and long-term adaptation measures that holistically target production systems and value chains key to the population's food security and livelihoods.

Remarkable efforts to build resilience of the crop and livestock producers have been evident in Makueni. These include on-farm practices that promote soil and water

conservation such as conservation agriculture, water harvesting through construction of sand dams, agroforestry, crop rotations, drought resistant and early maturing crop varieties, drought-tolerant animal breeds and irrigation, off-farm services such as extension, EWS and credit as well as policy legislation, where initiatives such as the Sand Act and the County Climate Change Fund have been developed.

Notwithstanding these efforts, farmers still struggle accessing inputs such as seeds and fertilisers and fundamental services such as extension. They rely on traditional strategies such as seed recycling and utilization of indigenous knowledge on disease control. Low technology adoption, driven mainly by high poverty levels and little access to productive inputs, has affected productivity. Storage of highly perishable commodities such as milk is still a problem in the County, given the high temperatures and low capacity to add value. Consequently, strategies that will seek to eliminate the underlying vulnerabilities such as poverty levels, poor access to water, education, and good roads. Additionally, ensuring timely provision of inputs, promoting collective action among farmers and upscale of community-level strategies (such as home and/or community nurseries), irrigation and feed conservation will go a long way in increasing the adaptive capacity of the people.

Also critical in addressing climate vulnerabilities is a harmonized institutional, policy and governance environment. The formulation and implementation of County-level climate change action plans that are grounded in assessment of local needs and resources could be an important step towards the operationalization of the country's climate strategy. This will include formulation of a climate change policy in addition to the existing Climate Change Fund and formation of a body responsible for coordinating climate change interventions to reduce duplication. Also, a policy on land use that will ensure secure tenure will reduce cases of interventions stalling due to land conflicts should be considered.

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

- Annex 1:** Administrative units and agroecological zones
- Annex 2:** Crop and livestock productivity in Makueni County
- Annex 3:** Climate analysis^o

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